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ABSTRACT

This document consists of materials for a six-unit course on the following topics: (1) power saw safety and maintenance; (2) cutting stock to length; (3) band machining and contouring; (4) drill press types and safety; (5) drill press work-holding devices; and (6) tools and tool holders. The instructor's guide begins with a list of competencies covered in the module, descriptions of the materials included, an explanation of how to use the materials, and information on how the curriculum guide is packaged. Next is a table that associates individual instructional materials in the units with the competencies they teach. The instructional units follow, each of which may include unit objectives, lesson objectives, lesson plans, references, notes to the teacher, information sheets or outlines, transparency masters, handouts, assignment sheets, job sheets, unit tests, and answers to tests. (CML)

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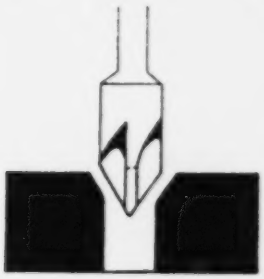
MACHINE SHOP CURRICULUM

INSTRUCTOR'S GUIDE

MODULE 4: Power Saw and Drill Press Operation



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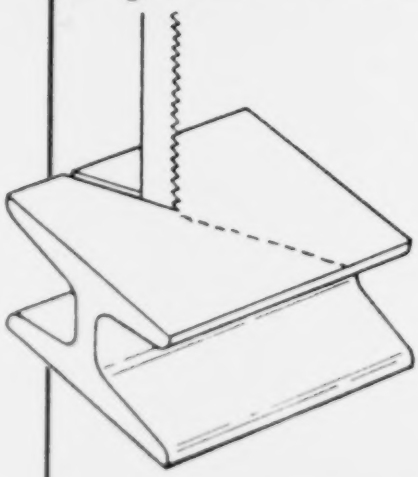

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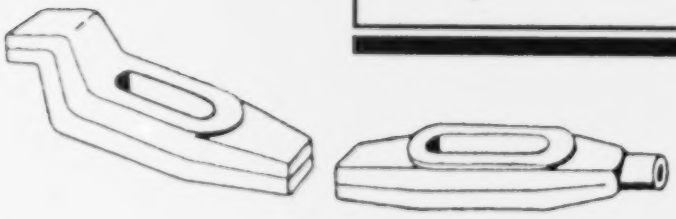

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2: *Measurement and Blueprint Reading* by Charles H. Walden, Don Marquardt and Henry "Junior" Cagle
3: *Bench Work and Material Science* by Charles H. Walden and Jack Nobles
4: *Power Saw and Drill Press Operation* by Charles H. Walden and Bill Daniel
5: *Lathes* by Jack Nobles
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MACHINE SHOP

Module 4: Power Saw and Drill Press Operation

by

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1989

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FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts and professionalism to develop curriculum for trade, technical and industrial education programs. This Machine Shop guide is an outstanding example of what can be accomplished when the right people with the right attitude get together. Committee members worked hard over several years' time in advisory, writing, technical consultation and field-test capacities.

This guide is designed to be totally integrated with the Vocational Instructional Management System. It is hoped that all guides produced under our supervision will help classroom teachers manage instruction. A curriculum guide is more than a resource--it is an integral part of the management system. Rather than impeding instruction, it should guide and facilitate instruction.

This guide's format has been set up for competency-based teaching and testing. Unit tests evaluate specific competencies and can be used with the Vocational Administrative Management System (VAMS). Information sheets, transparency masters, job sheets, assignment sheets and test items are keyed to specific competencies. A cross-reference table has been included to quickly identify parts of the curriculum that relate to specific competencies. The material has also been packaged for students.

Although this guide may be a new format for some teachers, we are confident that, when used as designed, time spent by teachers and students will become more productive. Any future machine shop curriculum modifications will begin with this guide. The machine shop field is undergoing considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

Judith Moore, supervisor
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Charles "Chuck" Waibel, director
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ACKNOWLEDGMENTS

This Machine Shop guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). The guide has been keyed to the machine shop competency profile developed by industry and education professionals in the state.

Appreciation is given to the writers (Charlie Walden, Jack Nobles, Dwight Crosswhite, Donna Curtis, Don Marquardt, Bill Daniel, Mel Gage and Jr. Cagle) for their technical expertise. Catherine Smith of Dodge Art Works, Columbia, created a large portion of the guide's artwork.

These industry representatives and educators contributed to the guide as members of the advisory committee.

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Support and contributions of IML staff members were instrumental to this module's development.

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COMPETENCIES ADDRESSED IN THIS MODULE

G. Operating Power Saws

1. Employ power saw safety guidelines consistently
2. Perform care and maintenance
3. Select proper blade type for sawing operations and materials
4. Cut and weld band saw blades
5. Select and set speeds and feeds on power saw
6. Cut material to length with power hack saw
7. Cut material to length with band saw
8. Select and apply cutting fluids
9. Contour saw to scribed line
10. Saw internal contours with band saw

H. Operating Drill Presses

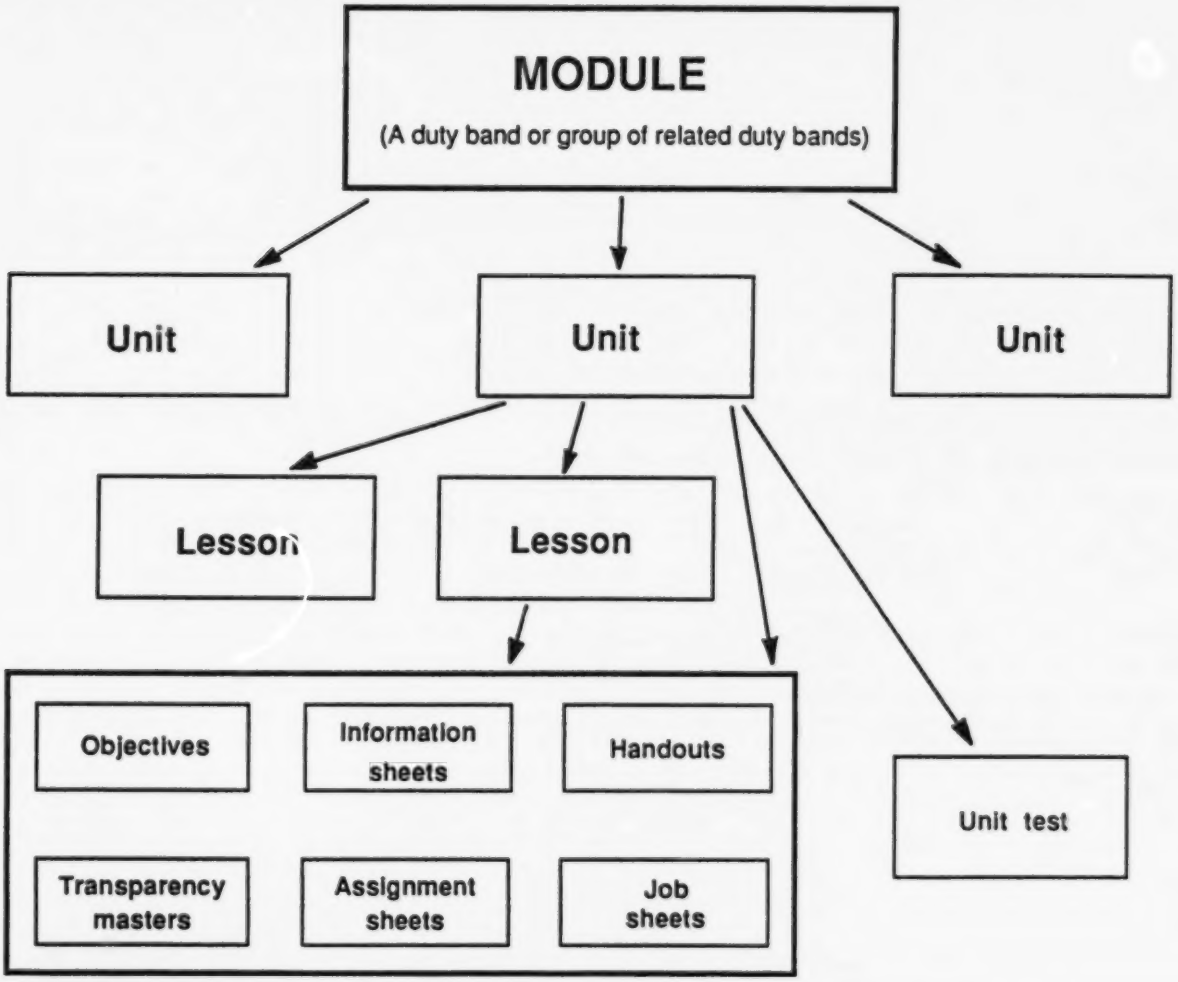
1. Employ drill press safety guidelines consistently
2. Perform care and maintenance
3. Set up and clamp workpiece to drill press table
4. Select proper drill type based on job requirements
5. Determine cutting tool variables prior to use
6. Set up drill press to obtain calculated feeds and speeds
7. Select and apply cutting fluids
8 Drill holes to specification using manual feed
9. Drill holes to specification using automatic feed
10. Counter sink hole to specifications
11. Counter bore hole to specifications
12. Spotface to specific dimensions
13. Mount workpiece on V-blocks
14. Power ream hole to size
15. Use drill jigs and bushings
16. Hand tap hole using drill press
17. Tap hole with tapping attachments
18. Sharpen drills with grinding attachments and/or specialized grinders
19. Set up radial drill press

HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Units of instruction

This Machine Shop guide contains eight modules of instruction. Within each module are instructional units including some or all of the following components: performance objectives, information sheets, transparency masters, handouts, assignment sheets, job sheets and a unit test. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section near the beginning of each unit.



Competency profile

On the Missouri competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral. To evaluate the student on performance of the competencies, a 3-2-1-N grading system is used, where:

- **3 = Mastery** - can work independently with no supervision
- **2 = Requires supervision** - can perform job completely with limited supervision
- **1 = Not mastered** - requires instruction and close supervision
- **N = No exposure** - no experience or knowledge in this area

Cross-reference table (color-coded white)

Once the numbering system is understood, this table quickly reveals how the instructional components of the module relate to Missouri competencies. On the competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral.

On the cross-reference table, unit numbers are represented by Roman numerals (I, II, III, etc.). Lessons within a unit are shown with Arabic numerals. Therefore, the first objective in Lesson 1 is numbered 1.1, the second is 1.2, and so on. Other components of the module (transparencies, handouts, assignment sheets and job sheets) also use this numbering system. By looking at the cross-reference table, the instructor can quickly determine what test questions or job sheets a student needs to receive an evaluation on a particular competency.

Objectives (color-coded white)

Each unit is based on performance objectives which state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives' intent. Teachers should feel free to add/adapt objectives which will fit the material to student and community needs. Supporting material will, of course, need to be added for any new objectives.

Table of contents, references, notes to the instructor (color-coded pink)

These pages have been coded pink for instructor use only. The reference section lists materials used as sources in developing the material. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section.

Information sheets (green)

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. **CAUTION** statements indicate possible equipment damage or bodily injury. Handouts and transparency masters have been keyed in the information sheets for instructional use.

Transparency masters (white)

Transparencies provide information by visually reinforcing or clarifying ideas presented in the information sheets. They are effective when identification is necessary and direct the class's attention to the topic of discussion. Transparencies should be left on the screen only when topics shown are under discussion, however.

Handouts (white)

Whenever more detailed information than can be presented in a transparency is needed, a handout is used. Handouts give the students additional information that can be kept with their class notes or student references.

Assignment sheets (tan)

Assignment sheets furnish paper-and-pencil practice to develop the knowledge necessary as a prerequisite to skill development. They can be given to students for class completion or used as homework assignments. Answer sheets (color-coded pink) can be used by the student or instructor to check progress.

Job sheets (blue)

These evaluation instruments are provided for two purposes: to outline steps of procedure and to check student performance mastery. Job sheets begin with a list of tools and materials needed for the activity. Job sheets furnish potential employers with a picture of skills being taught and performance which might be reasonably expected from a vocational student. The spaces to the right of the page on a job sheet

assist the instructor in evaluating a student on a particular activity. This 3-2-1-N grading system is the same as the one used on the competency profile.

Unit test (yellow)

Competency-based tests are designed to help eliminate subjective testing and to improve student evaluation and accountability. Specific competencies and test questions are linked on the answer key. These unit tests have been written to be used with computerized VAMS (Vocational Administrative Management System), utilizing Scantron sheets for computer-recording of test answers.

The unit test may be eliminated if the competency was thoroughly evaluated by job sheets. However, an emphasis should be placed on cognitive as well as performance skills. If the objective or competency will be evaluated by a job sheet, it is often necessary to determine by a written test whether the student understands enough of the material to perform the job sheet.

SUGGESTED ACTIVITIES

The following list of suggested activities may be helpful, especially to the beginning instructor.

1. Provide students with objective sheet and information sheets.
2. Discuss unit and specific objectives.
3. Discuss information sheets, assignment sheets and/or job sheets, lesson-by-lesson.
4. Have students do assignment sheet(s) to satisfactory levels.
5. Give students unit test.
6. After successful completion of the test, have students do job sheet(s).

Students should perform the following activities.

1. Read objective sheet.
2. Study information sheets.
3. Do assignment sheet(s).
4. Take unit test.
5. Do job sheets.

PACKAGING

This Machine Shop guide has been packaged with the entire class in mind. For the teacher, a complete instructor's guide contains all eight modules. In the student reference, selected portions have been reproduced for student use (objectives page, information sheets, handouts). Student work sheets (assignment sheets, job sheets, unit tests) have been packaged together for student distribution as the instructor deems necessary.

In the student reference, page numbers do not run consecutively because some pages have been removed that appear only in the instructor's guide.

MODULE 4: POWER SAW AND DRILL PRESS OPERATION

CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
G1	I 1.3, II 1.3-1.4				II 1.1-1.2	I 5-6, II 4	
G2	I 2.1-2.2, II 1.3-1.4				II 1.1-1.2	I 11-12	
G3	I 3.1, III 1.2					I 16-25,32	
G4	I 2.3	I 2.1			I 2.1	I 7-10,13-15	
G5	I 4.1-4.3, II 1.3-1.4				II 1.1-1.2	I 26,28-31	
G6	II 1.1-1.3	II 1.1			II 1.1	II 1-3,5	
G7	I 3.2, II 1.4				II 1.2	II 2,3,5	
G8	II 1.3-1.4				II 1.1-1.2	I 27	
G9	III 1.3				III 1.1		
G10	III 1.1-1.2,1.4	III 1.1-1.3			III 1.1	III 3-5	
H1	IV 2.1-2.3					IV 1-28	
H2	VI 2.5				VI 2.2		
H3	V 1.1,1.2				V 1.1,1.2	V 1-20	
H4	IV 1.1-1.4	IV 1.1	IV 1.1,1.2	IV 1.1		IV 29-44	
H5	V 1.4					V 21-25	
H6	VI 1.1,1.2,2.1-2.3	VI 2.1	VI 1.1,2.1-2.3	VI 1.1,2.1	VI 2.1	VI 1-12	
H7	V 1.5				V 1.1,1.2		Also see the Lathes module and mfg. specs.

Competency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
H8	VI 2.4				VI 2.1		
H9	VI 2.4				VI 2.1		
H10	VI 2.8				VI 2.5		
H11	VI 2.7				VI 2.4		
H12	VI 2.7				VI 2.4		
H13	V 1.3,1.6				V 1.2	V 26	
H14	VI 2.6				VI 2.3		
H15	V 1.5	V 1.1	V 1.1		V 1.1		
H16	VI 2.9				VI 2.6		
H17	VI 2.12				VI 2.9		
H18	VI 2.11				VI 2.7,2.8		
H19	VI 1.3					VI 24	

MODULE: POWER SAW AND DRILL PRESS OPERATION
UNIT I: POWER SAW SAFETY AND MAINTENANCE

UNIT OBJECTIVE

In this unit the student will identify the various types of power saws used in metalworking and practice safe practices and maintenance procedures for power saws. Additionally, the student will learn principles concerning selection of saw blades, speeds and feeds, and cutting fluids for power sawing. This knowledge will be evidenced by achieving the specified score on the job sheet and unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

1.1 Identify types of power saws.

1.2 Describe applications of various power saws.

1.3 Employ power saw safety guidelines. (competency G1)

2.1 Describe and perform care and maintenance for cutoff saws. (competency G2)

2.2 Describe and perform care and maintenance for vertical band saws. (competency G2)

2.3 Cut and weld band saw blades. (competency G4, JS 2.1)

3.1 Describe power hacksaw blade principles and configurations. (competency G3)

3.2 Identify band saw selection considerations.

4.1 Discuss speeds, feeds and cutting fluids for power hacksaws.

4.2 Discuss speeds, feeds and cutting fluids for horizontal cutoff saws.

4.3 Discuss speeds, feeds and cutting fluids for vertical band (contouring) saws. (competency G5)

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT I: POWER SAW SAFETY AND MAINTENANCE

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: TYPES OF POWER SAWS AND THEIR APPLICATIONS

   a. Information outline

2. Lesson 2: POWER SAW SAFETY

   a. Information outline

   b. Transparency master

      TM 2.1: Preparation for butt welding

   c. Job sheet

      JS 2.1: Cut and weld band saw blades

3. Lesson 3: SELECTION OF SAW BLADES

   a. Information outline

4. Lesson 4: SPEEDS, FEEDS AND CUTTING FLUIDS

   a. Information outline

E. Unit test

F. Answers to unit test

REFERENCES

A. Books/manuals

1. "DoAll Contour Milling Machines" (Operator's Instruction Manual). Minneapolis: Continental Machines, Inc., 1943.

2. Olivo, C. Thomas. Advanced Machine Tool Technology. North Scituate, MA: Breton Publishers, 1982.

3. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT I: POWER SAW SAFETY AND MAINTENANCE

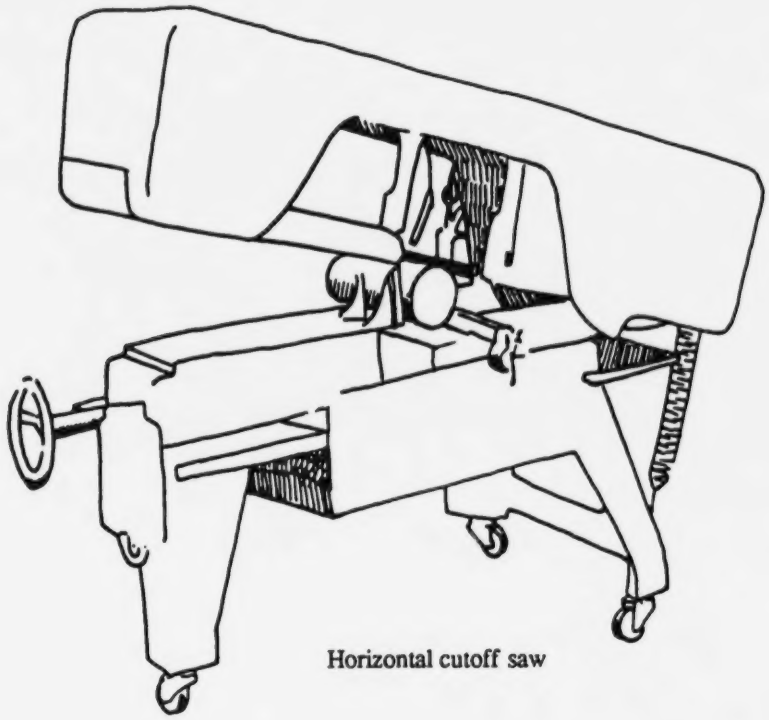
LESSON 1: TYPES OF POWER SAWS AND THEIR APPLICATIONS

I. Types of power saws

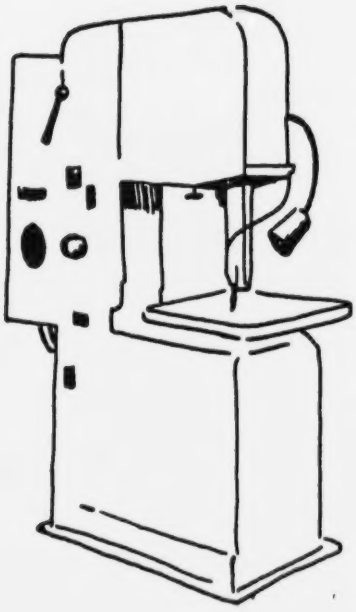
- A. Stock cutoff saws
  - 1. Power hacksaw
  - 2. Horizontal band saw
  - 3. Cold saw
- B. Contouring saw/vertical band saw

II. Principles of operation

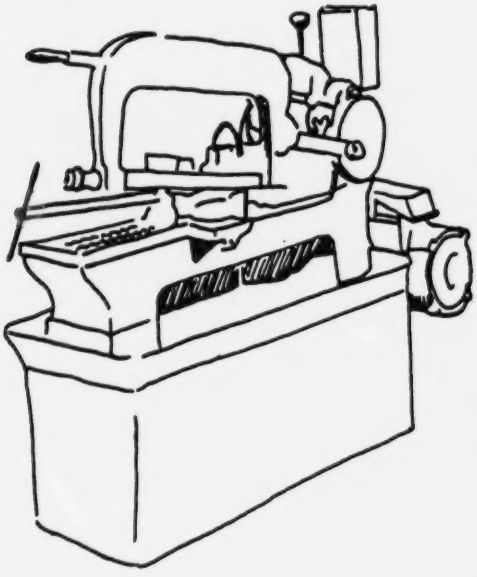
- A. Power hacksaw
  - 1. For cutting stock to length
  - 2. Reciprocating action
    - a. Blade moves back and forth
    - b. Cutting occurs in only one direction
- B. Horizontal band saw
  - 1. For cutting stock to length
  - 2. Uses a continuous band in horizontal orientation
  - 3. Cuts at all times when blade is in contact with workpiece
- C. Cold saw
  - 1. For cutting stock to length
  - 2. Uses low rpm circular blade
  - 3. Provided with swivel head for cutting at various angles
- D. Vertical band saw
  - 1. For cutting complex contours, both internal and external
  - 2. Uses a continuous band in a vertical orientation



Horizontal cutoff saw



Vertical band saw



Power hacksaw

III. Power saw safety

A. Stock cutoff machines

1. Always wear safety glasses when operating a stock cutoff machine.

2. Turn off power before handling workpieces.

3. Clamp workpiece securely to prevent binding and breaking of blade.

4. Check condition of blade before operating. Do not use blades which are worn or damaged.

5. Operate at proper speed.

6. Take care in handling workpieces removed from the saw. They will have sharp edges and burrs and may also be very hot.

7. Support long stock. Do not allow it to extend into aisles and other areas where it can create a tripping hazard.

CAUTION: Above all else, KEEP HANDS AWAY FROM THE BLADE WHILE IT IS IN OPERATION!

B. Vertical band saws

NOTE: The greatest danger in operating a vertical band saw is that the operator must often hold the workpiece by hand and feed it into the blade. Extra care must be taken to avoid injury to the hands.

1. Always wear safety glasses when operating a vertical band saw.

2. Check condition of blade before operating. Do not use blades which are worn or damaged.

3. Operate at proper speed.

4. When feeding workpiece by hand, do not use excessive force.

5. Hold small workpieces with locking pliers or clamps. Keep hands clear of blade at all times when it is running.

6. Take care in handling workpieces after sawing. They will have sharp edges and burrs and may also be very hot.

7. Set saw guide close to the top of the workpiece (within 1/8-1/4" of the top of the workpiece). This will minimize the amount of exposed blade and reduce the risk of injury if the hands slip while feeding.

8. Stand to one side of the saw when starting. This will keep you clear of the saw if the blade should break.

9. Use a stick to remove short pieces from near the blade.

CAUTION: Above all else, KEEP HANDS AWAY FROM THE BLADE WHILE IT IS IN OPERATION!

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT I: POWER SAW SAFETY AND MAINTENANCE

LESSON 2: POWER SAWS SAFETY

NOTE: Always follow manufacturer's instructions for maintenance and operation of equipment.

I. General maintenance of cutoff saws

- A. Use general-purpose machine oil such SAE 20 or SAE 30.
- B. Lubricate thrust bearings and motor bearings if not sealed.
- C. Lubricate all other pivot points.
- D. Check level in gearbox (if any). Heavy gearbox lubricant should be added if level is low.
- E. Lubricate slides on power hacksaw.

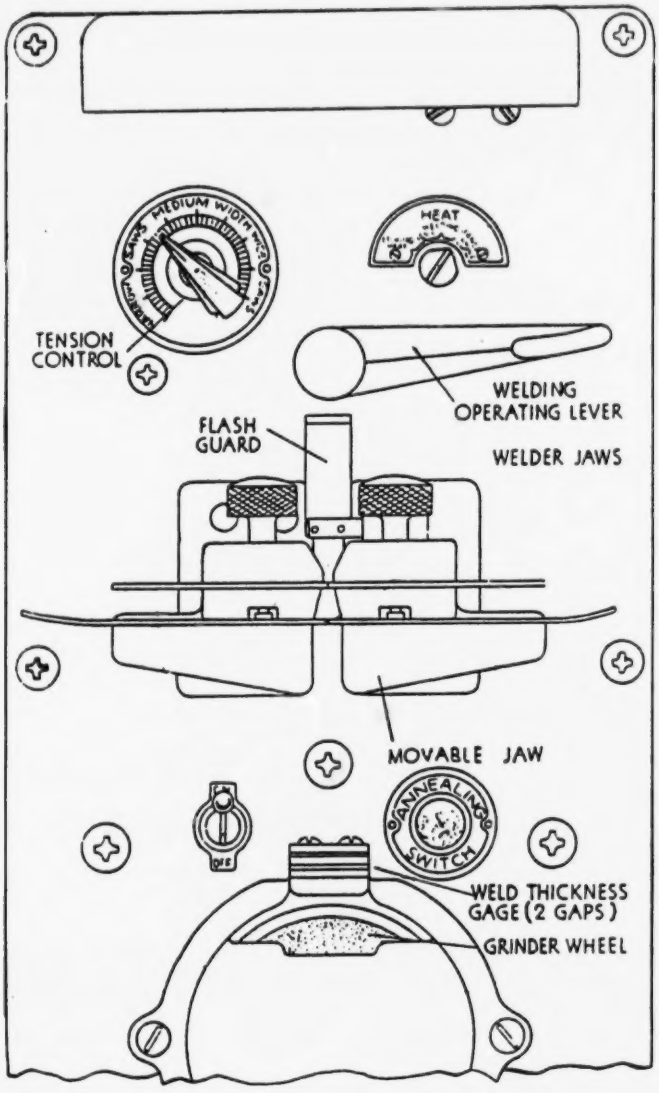
II. General maintenance of vertical band saws

- A. Most saws are equipped with sealed bearings and may require little maintenance.
- B. Oil the variable-speed pulley per manufacturer's instructions.
- C. Oil motor bearings if necessary.
- D. Occasional light lubrication of the post holding the blade guides will keep it moving freely.
- E. Check level in gearbox. Heavy gearbox lubricant should be added if level is low.

III. Butt welding band saws

- A. Reasons for welding band saws
  1. Saws are made from long stock cut to length, then butt welded.
  2. Saws can break and need to be rewelded.
  3. Saw are often broken intentionally to permit the cutting of internal contours.

B. Parts of a butt welder



Credit: Adapted from "DoAll Contour Milling Machines" (Operator's Instruction Manual). Minneapolis: Continental Machines, Inc., 1943.

C. Procedure for butt welding **(TM 2.1)**

1. Grind the ends of the band saw blade square.
2. Check ends for squareness and straightness.
3. Clamp the ends in the butt welder.
4. Adjust tension (voltage).
5. Put flash guard down and press the operating lever to complete weld.

NOTE: If weld is not good, cut off ends and re-weld. There should be only one weld in a band.

6. Anneal the blade pressing the anneal button. Allow the weld to heat to a dull, cherry red color. Do not overheat.

   NOTE: Annealing is necessary because the welding process makes the weld brittle.

7. Remove flash with grinder.

8. Check thickness of blade. Weld area should be no thicker than the rest of the blade.

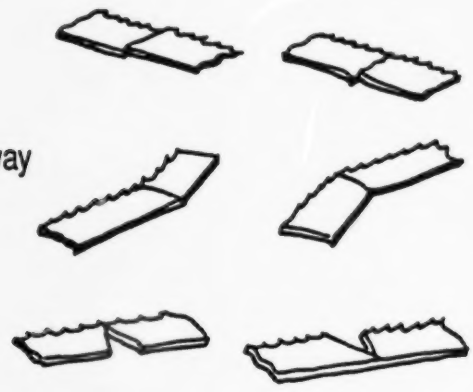
PREPARATION FOR BUTT WELDING

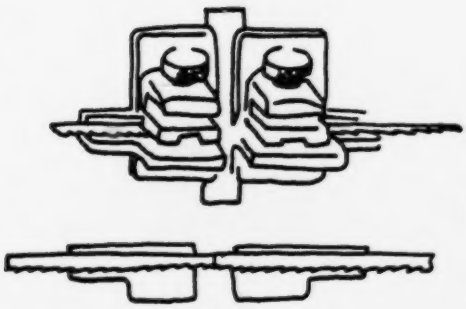
Grind ends as shown.

Right way

Lay out blade ends.

Wrong way





Clamp the blade in the welder.

NOTE: Square saw ends before welding. Back of saw must be straight.

CUT AND WELD BAND SAW BLADE

Equipment:

Pedestal grinder
Assortment of short pieces of band saw blade (6-8" long)
Butt welder with grinder
Compound hand shear
0-1" micrometer

Procedure:		Evaluation 3	2	1	N
1.	Grind the blade ends with the pedestal grinder so that they are square.	—	—	—	—
2.	Butt ends together to be sure the ends of the saw match and that there are no gaps between the ends. Also check that the back edge of the saw is straight.	—	—	—	—
3.	Clamp the blade ends in the butt welder with the contact point of the ends centered between the clamps.	—	—	—	—
4.	Adjust tension (voltage) in accordance with the width of the blade.	—	—	—	—
5.	Put flash guard down. Press the operating lever to make the weld. Inspect weld for blowout or incomplete areas. If weld is not continuous, remove blade, cut off weld with hand shears and start over.	—	—	—	—
6.	Lift flash guard. Press anneal button until weld area becomes a dull cherry red.	—	—	—	—
7.	Remove blade from clamps and grind away flash on both sides using butt welder grinder.	—	—	—	—
8.	Check thickness of weld zone using thickness gage or micrometer. Weld should be no thicker than the rest of the blade.	—	—	—	—

Average of evaluations above*

*This average is the student's final evaluation for competency G4: Cut and weld band saw blades.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT I: POWER SAW SAFETY AND MAINTENANCE

LESSON 3: SELECTION OF SAW BLADES

I. Power hacksaws

A. Principles

1. At least two teeth must contact the work at all times.

2. Soft, ductile materials require coarse teeth.

3. Thin webs and parts with small cross-sections require finer teeth.

4. Hard materials require finer teeth.

B. Pitch/standard tooth per inch (tpi) configurations: 4, 6, 8, 10, 14, 18, 24

Material Being Cut	Machinability Group*	Pitch of Teeth Minimum Material Thickness				
		6 mm (1/4")	12 mm (1/2")	18 mm (3/4")	25 mm (1")	50 mm (2") or over
Easily machined	1 (above 70%)	2.5 mm (10)**	4 mm (6)	4 mm (6)	6 mm (4)	6 mm (4)
Moderately difficult to machine	2 (50 - 70%)	2.5 mm (10)	2.5 mm (10)	4 mm (6)	4 mm (6)	6 mm (4)
Difficult to machine	3 (40 - 50%)	2.5 mm (10)	2.5 mm (10)	2.5 mm (10)	4 mm (6)	4 mm (6)

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C. Other considerations

1. Standard material is high-speed steel.

2. Blade length must be appropriate for saw.

II. Band saws

A. Horizontal band saws--selection considerations

1. Material

a. Carbon steel

b. Alloy steel

c. High-speed steel--preferred because of long service life relative to other types

d. Composite--high-speed steel or carbide teeth on a carbon steel back

2. Tooth form

   a. Use a regular tooth form for workpieces up to 1" thick.

   b. Use hook teeth for thick workpieces (more than 1").

3. Pitch

Workpiece Thickness	Blade Width	Pitch
up to 16 mm (5/8")	25 mm (1")	2.5 mm (10*)
16 mm (5/8") to 25 mm (1")	25 mm (1")	3 mm (8)
25 mm (1") to 100 mm (4")	25 mm (1")	4 mm (6)
100 mm (4") to 250 mm (10")	25 mm (1") to 32 mm (1-1/4")	6 mm (4)
250 mm (10") to 500 mm (20")	32 mm (1-1/4") to 50 mm (2")	8 mm (3)

*Teeth per inch.

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B. Vertical band saws (contouring saws)

1. Materials

   a. Carbon steel

   b. High-speed steel

   c. Composite (with welded tungsten carbide or high-speed steel teeth)

2. Form

Regular Hook Skip

   a. Regular--used for all blades with 6 tpi or more

   b. Hook--for blades with teeth coarser than 6 tpi

   c. Skip--provide adequate chip clearance for soft, ductile materials

3. Pitch is determined by thickness of the material being cut. Most importantly, thin materials require finer teeth.

4. Blade set

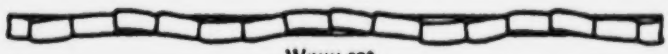
Raker set

a. Raker--recommended for contouring applications

Straight set

b. Wavy

c. Straight


Wavy set

5. Width--an important consideration in contouring. Refer to Unit III of this module for additional information.

C. Additional considerations for band saws

1. Storage

a. Blades are stored in a folded condition.

b. Hold blade hanging in one hand with bottom of loop touching floor.

c. Step lightly onto blade.

d. Twist blade while moving hand toward floor.

e. Blade will form a tight circle.

f. Store in slotted storage unit. Blades should not be allowed to touch each other.

2. Determining proper length of saw blade

NOTE: This step is important, whether your shop welds blades from stock or orders blades pre-welded.

a. Open upper and lower wheel covers.

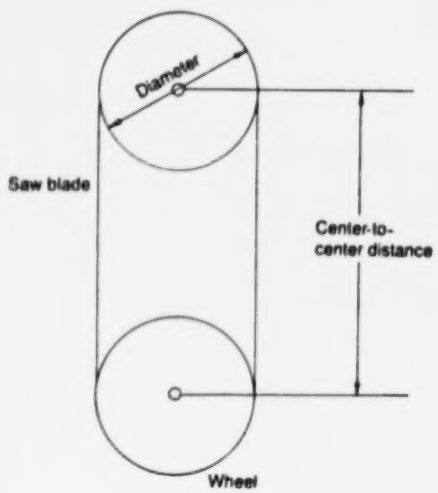
b. Measure diameter of one wheel.

c. Measure distance between wheel centers.

NOTE: Have wheels adjusted at about mid-range between their closest and furthest settings. Otherwise, the measurement may yield a saw length which is too short or too long.

d. Calculate circumference of wheel--pi (π) x diameter

NOTE: Sufficient accuracy is obtained by using a value of 3.14 for pi.



e. Add circumference to 2 x center-to-center distance.

π (dia) x 2 (c) = length of blade stock

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT I: POWER SAW SAFETY, MAINTENANCE & SETUP

LESSON 4: SPEEDS, FEEDS AND CUTTING FLUIDS

I. Power hacksaws

A. Feed

1. By weight of saw overarm
2. Can be hydraulically controlled

B. Speed

1. Expressed in strokes per minute

   NOTE: Power hacksaws generally have a limited number of settings. Pick the setting closed to the one desired.

2. Set speed according to material being cut.

C. Use approved water-soluble coolant flood to keep blade cool and increase life.

II. Horizontal cutoff saw

A. Feed--controlled by hydraulic cylinder; adjusted manually, no specific setting.

B. Speed: Most simpler machines have only one operating speed.

C. Coolant: Use approved water-soluble coolant flood to keep blade cool and increase life.

III. Vertical band saws (contouring saws)

A. Speed-control mechanisms

1. Gearbox: Machine must be stopped to change gears.
2. Variable speed drive: Machine must be running to change speeds.

B. Feed

1. Hand feed is used on small workpieces.
2. Power/automatic feed is used on large workpieces or for production work.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT I: POWER SAW SAFETY AND MAINTENANCE

UNIT TEST

Select the option which best answers the question or completes the statement.

___ 1. All of the following are cutoff saws except which one?

a. Vertical band saw
b. Horizontal band saw
c. Cold saw
d. Power hacksaw
e. None of the above

___ 2. Which saw has a reciprocating action?

a. Power hacksaw
b. Vertical band saw
c. Cold saw
d. Mill saw
e. None of the above

___ 3. Which saw uses a circular blade operated at low rpm?

a. Vertical band saw
b. Cold saw
c. Horizontal band saw
d. Power hacksaw
e. None of the above

___ 4. Which saw is used for cutting complex internal and external contours?

a. Cold saw
b. Vertical band saw
c. Horizontal band saw
d. Mill saw
e. None of the above

___ 5. Which is the most important safety consideration when operating power saws?

a. Provide for proper lubrication.
b. Keep hands clear of the blade when it is running.
c. Keep feet spread slightly apart.
d. Clear table of debris.
e. Wear steel-toed safety shoes.

___ 6. Why can the operation of a vertical band saw be especially dangerous?

a. The blade travels at high speed.
b. Burrs can form on workpieces.
c. Work is often fed by hand, and it is often necessary to work close to the moving blade.
d. Long stock must be supported.
e. All of the above

___ 7. Which is not a reason for welding a saw blade?

a. Several short sections of band can be welded together to form a full-length saw blade.
b. Blades can be formed from band stock.
c. Blades can break and require re-welding.
d. Saws must be broken and re-welded to permit internal sawing.
e. None of the above

___ 8. Which is not a step in preparation of the band ends for welding?

a. Grind the ends square.
b. Remove any flash.
c. Check for squareness.
d. Check for straightness.
e. Clamp bands in the butt welder jaws.

___ 9. How is welding is accomplished?

a. By turning the tension control knob
b. By annealing
c. By pressing the operating lever
d. By turning clamp handles
e. None of the above

___ 10. When annealing, the weld area should be what color?

a. Straw
b. Dark purple
c. Blue
d. Dull cherry red
e. Bright red

___ 11. What is the most important guideline for maintaining cutoff saws?

a. Consult the instructor or supervisor first.
b. Use general-purpose machine oil, such as SAE 40 or SAE 50.
c. Follow manufacturer's instructions.
d. Occasionally lubricate the post holding the blade guides lightly.
e. Check gearbox lubricant; add lightweight lubricant when low.

___ 12. What is the most important guideline for maintaining vertical band saws?

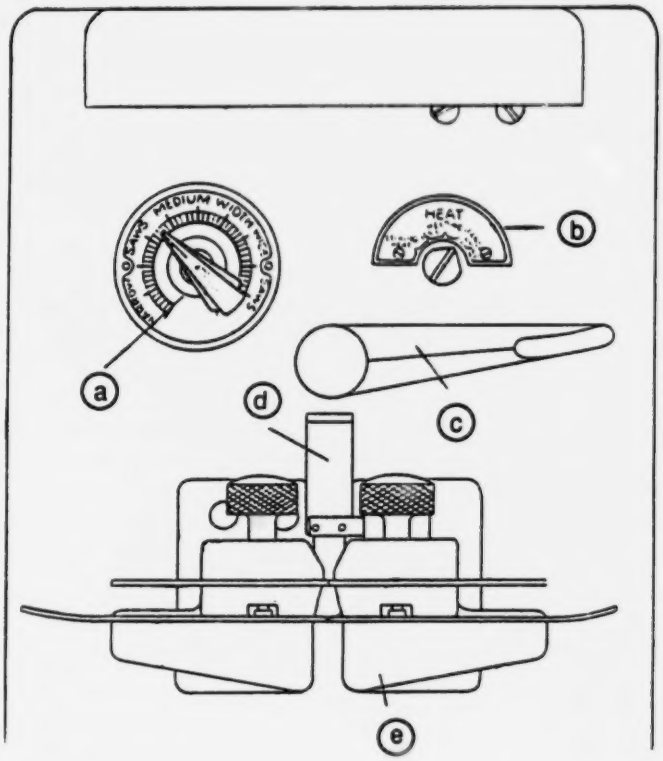
a. Consult the instructor or supervisor first.
b. Use general-purpose machine oil, such as SAE 40 or SAE 50.
c. Follow manufacturer's instructions.
d. Occasionally lubricate the post holding the blade guides lightly.
e. Check gearbox lubricant; add lightweight lubricant when low.

Identify the parts of the butt welder in the illustration below.

___ 13. Welding operating lever

___ 14. Tension control

___ 15. Flash guard



Credit: "DoAll Contour Milling Machines" (Operator's Instruction Manual). Minneapolis: Continental Machines, Inc., 1943.

Select the option which best answers the question or completes the statement.

___ 16. As a general rule, what is the minimum number of power hacksaw teeth which must be in contact with the workpiece?

a. 1
b. 2
c. 4
d. 6
e. 8

___ 17. Which type of material would require the finest saw teeth?

a. Soft copper
b. Steel
c. Aluminum
d. Plastic
e. None of the above

___ 18. What is another term for teeth per inch?

a. Lead
b. Pitch
c. Helix
d. Capacity
e. None of the above

___ 19. Which is a common material for power hacksaw blades?

a. Carbon steel
b. Diamond impregnated
c. High-speed steel
d. Carbide insert
e. None of the above

___ 20. In horizontal band saw cutoff, which tooth configuration is best suited for thicker workpieces?

a. Regular
b. Hook
c. Gullet
d. Skip
e. Raker

___ 21. Which describes a composite saw blade?

a. Hardened teeth welded to a soft back such as carbon steel
b. Carbon fibers throughout for high flexibility
c. Fiberglass fibers throughout for high strength
d. Never used in cutoff work
e. None of the above

___ 22. Which tooth configuration is used to saw soft, ductile materials?

a. Regular
b. Hook
c. Skip
d. Intermittent
e. None of the above

___ 23. Which is true with respect to contour sawing of thin materials?

a. More teeth per inch are required.
b. A skip tooth blade should be used.
c. Fewer teeth per inch are required.
d. Teeth must be sharper.
e. None of the above

___ 24. Which is a factor in blade selection for contouring?

a. Blade pitch
b. Overarm setting
c. Blade width
d. Regular pitch
e. None of the above

___ 25. Identify the type of blade set illustrated below.

a. Raker
b. Wavy
c. Straight
d. Skip
e. Hook

___ 26. Power hacksaw speed is expressed in which unit?

a. Surface feet per minute
b. Meters per minute
c. Millimeters per minute
d. Strokes per minute
e. None of the above

___ 27. What is the purpose of using coolant with a cutoff saw?

a. Keeps workpiece cool
b. Lubricates and cools blade, extending blade life
c. Lubricate reciprocating parts
d. Keeps machine operating properly
e. None of the above

___ 28. How is feed on horizontal band saws controlled?

a. By computer-assisted CNC
b. Manually with a small hydraulic cylinder
c. By servo-motors
d. By the weight of the overarm
e. None of the above

___ 29. Why isn't speed a consideration on many horizontal cutoff saws?

a. Most materials to be cut have very similar properties.
b. There is only one speed setting.
c. The blades are extremely sharp and durable.
d. Blade guides prevent excessive wear on moving parts.
e. None of the above

___ 30. When changing gears on a vertical band saw, which of the following is true?

a. The saw must be brought to a complete stop.
b. The saw must be in motion.
c. The clutch release lever must be held in the upright position.
d. The saw can be stopped or in motion.
e. None of the above

___ 31. For most small work, how is feed accomplished?

a. By hand
b. By direct drive
c. By power or automatic means
d. By increasing saw blade rpm
e. None of the above

___ 32. Calculate the proper length of band saw stock for band saw with 15" wheels with 18" between wheel centers.

a. 33"
b. 48"
c. 83.1"
d. 144"
e. None of the above

ANSWERS TO UNIT TEST

1.	a	
2.	a	
3.	b	
4.	b	
5.	b	(G1)
6.	c	(G1)
7.	a	(G4)
8.	b	(G4)
9.	c	(G4)
10.	d	(G4)
11.	d	(G2)
12.	d	(G2)
13.	c	(G4)
14.	a	(G4)
15.	d	(G4)
16.	b	(G3)
17.	b	(G3)
18.	b	(G3)
19.	c	(G3)
20.	b	(G3)
21.	a	(G3)
22.	c	(G3)
23.	a	(G3)
24.	c	(G3)
25.	a	(G3)
26.	d	(G5)
27.	b	(G8)
28.	b	(G5)
29.	b	(G5)
30.	a	(G5)
31.	a	(G5)
32.	c	(G3)

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT II: CUTTING STOCK TO LENGTH

UNIT OBJECTIVE

In this unit the student will learn principles and practices related to the operation of power cut-off saws. The student will learn how to operate both power hacksaws and horizontal band saws for this purpose. This knowledge will be evidenced by achieving the specified score on job sheets and the unit test.

SPECIFIC OBJECTIVES

Upon completion of this unit, the student should be able to:

1.1 Identify work-holding practices for cut-off saws.

1.2 Describe other considerations when using cut-off saws.

1.3 Cut material to length with power hacksaw employing safety guidelines. (competency G6; partial G1, G2, G5, G8; JS 1.1)

1.4 Cut material to length with band saw employing safety guidelines. (competency G7; partial G1, G2, G5, G8; JS 1.2)

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT II: CUTTING STOCK TO LENGTH

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: POWER HACKSAWS

   a. Information outline

   b. Transparency master

      TM 1.1: Work-holding methods for cut-off sawing

   c. Job sheet

      JS 1.1: Cut material to length with power hacksaw
      JS 1.2: Cut material to length with band saw

E. Unit test

F. Answers to unit test

REFERENCES

A. Books/manuals

1. "DoAll Contour Milling Machines" (Operator's Instruction Manual). Minneapolis: Continental Machines, Inc., 1943.

2. Olivo, C. Thomas. Advanced Machine Tool Technology. North Scituate, MA: Breton Publishers, 1982.

3. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. The job sheets in this unit require cutting stock to length. Use any readily available, inexpensive stock for these operations--angle, channel, bar, etc.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT II: CUTTING STOCK TO LENGTH

LESSON 1: POWER HACKSAWS

I. Work-holding practice for cut-off saws **(TM 1.1)**

A. Square a fixed vise with a combination square.

B. Vises can be swiveled for angular cutting or held at right angles to saw blade for straight cutoff.

C. Hold workpiece securely. See below for suggested practices for various workpiece shapes.

D. Multiple pieces of the same shape can be nested together to increase productivity.

II. Other considerations

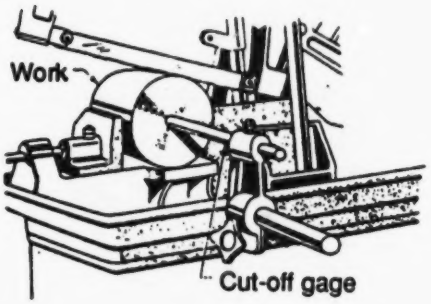
A. Use of a cutoff gage can speed up cutoff operations. Adjust gage to desired cutoff length. Push stock against gage after each cut.

B. Set the blade down at the level of the workpiece for more accurate measurement.

C. Support long stock as needed.

D. Many saws are equipped with a lever which will shut the machine off automatically when a cut is completed. Check the operation of this device before beginning.

E. In many instances bars of steel and other material are color-coded on their ends to indicate the type of material. Avoid cutting off the color-coded end as it might difficult or impossible for the next user to determine the composition of the remaining stock once it is placed back into storage.



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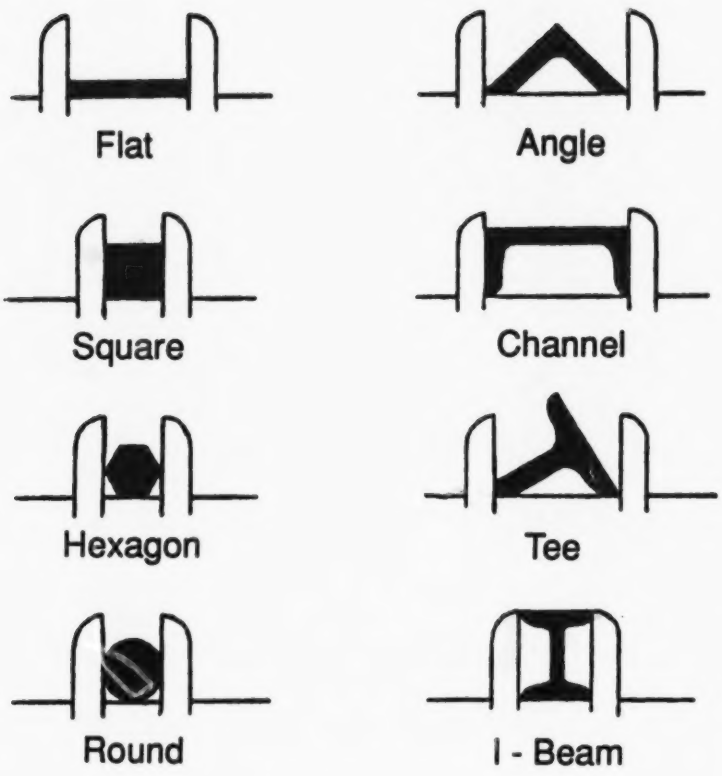
III. Safety

A. Do not pick up part--it might be very hot.

B. Avoid sharp burrs which might have been produced by the sawing operation.

C. Do not attempt to remove stock until the saw has come to a complete stop.

WORK-HOLDING METHODS FOR CUTOFF SAWING



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CUT MATERIAL TO LENGTH WITH POWER HACKSAW

Equipment:

Power hacksaw
Bench rule
Combination square
Adjustable wrench
Angle, channel or other stock

Procedure:	Evaluation 3	2	1	N
1. Lubricate machine per manufacturer's instructions; check and adjust blade tension as necessary. Check operation of automatic shut-off switch, if present.	—	—	—	—
2. Set fixed vise jaw square with combination square. Tighten with adjustable wrench.	—	—	—	—
3. Lower blade and set stock cutoff gage to 3" using bench rule.	—	—	—	—
4. Mount stock in vise with end against cutoff gage.	—	—	—	—
NOTE: Avoid cutting off color-coded end of workpiece.				
5. Determine desired blade speed from table and set as closely as the machine gearbox will permit.	—	—	—	—
6. Start coolant flow. Start saw. Lower blade against workpiece to begin cut. Observe blade operation throughout cut.	—	—	—	—
7. Shut off machine when cut is complete. Advance stock against cutoff gage and repeat as instructor requires.	—	—	—	—
CAUTION: Do not pick up part as it might be very hot. Also, avoid sharp burrs which might have been produced by the sawing operation. Do not attempt to remove stock until the saw has come to a complete stop.				
8. Deburr workpieces with file. Deburr stock and return to storage.	—	—	—	—
Average of evaluations above*	—	—	—	—

*This average is the student's final evaluation for competency G6. It is also one-third the evaluation for G1, G2 and G5 and one-half the evaluation for G8.

CUT MATERIAL TO LENGTH WITH BAND SAW

Equipment:

Horizontal band saw
Bench rule
Combination square
Adjustable wrench
Angle, channel or other stock

Procedure:	Evaluation 3	2	1	N
1. Lubricate machine per manufacturer's instructions; check and adjust blade tension as necessary. Check operation of automatic shut-off switch, if present.	—	—	—	—
2. Set fixed vise jaw square with combination square. Tighten with adjustable wrench.	—	—	—	—
3. Lower blade and set stock cutoff gage to 3" using bench rule.	—	—	—	—
4. Mount stock in vise with end against cutoff gage.	—	—	—	—
NOTE: Avoid cutting off color-coded end of workpiece.				
5. Start coolant flow. Start saw. Lower blade against workpiece to begin cut. Observe blade operation throughout cut.	—	—	—	—
6. Shut off machine when cut is complete. Advance stock against cutoff gage and repeat as instructor requires.	—	—	—	—
CAUTION: Do not pick up part as it might be very hot. Also, avoid sharp burrs which might have been produced by the sawing operation. Do not attempt to remove stock until the saw has come to a complete stop.				
7. Deburr workpieces with file. Deburr stock and return to storage.	—	—	—	—
Average of evaluations above*	—	—	—	—

*This average is the student's final evaluation for competency G7. It is also one-third the evaluation for G1, G2 and G5 and one-half the evaluation for G8.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT II: CUTTING STOCK TO LENGTH

UNIT TEST

Select the option which best answers the question or completes the statement.

___ 1. How are angular cuts made on a cutoff saw?

a. Holding the workpiece with one end higher than the other
b. Swiveling the vise to the desired angle
c. Turning blade guides to the desired angle
d. It is not possible
e. None of the above

___ 2. Why is it important to avoid cutting off the color coding on the end of a bar of stock?

a. Coding indicates the material type.
b. Coding indicates overall hardness.
c. The next user might not know what the type of material.
d. Color coding tells what type of saw to use.
e. None of the above

___ 3. Which device can increase the speed of cutoff saw set-up?

a. Cutoff gage
b. Coolant control
c. Blade tension screw
d. Overarm adjustment plate
e. None of the above

___ 4. Which statement best describes the condition of a workpiece immediately after cutoff?

a. It is hot and has sharp burrs.
b. It is cleanly cut and is safe to handle.
c. It might have burrs but will be cool to the touch.
d. It will be held in the work-holding vise.
e. It will be easily machined.

___ 5. Which tool is used to square a fixed vise jaw?

a. Bench rule
b. Combination square
c. Dial caliper
d. Dial gage
e. None of the above

ANSWERS TO UNIT TEST

1. b (G6)
2. c (G6, 7)
3. a (G6, 7)
4. a (G1)
5. b (G6, 7)

MODULE: POWER SAW AND DRILL PRESS OPERATION
UNIT III: BAND MACHINING/CONTOURING

UNIT OBJECTIVE

In this unit the student will learn principles and practices concerning the operation of a vertical band saw to do contour cutting. This knowledge will be evidenced by achieving the specified score on the job sheet and unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

1.1 Describe the operation of a vertical band saw.

1.2 Select a blade for contour sawing. (competencies G3 and G10)

1.3 Contour saw to a scribed line. (competency G9, JS 1.1)

1.4 Saw internal contours with band saw. (competencies G1, G2, G5 and G10, JS 1.1)

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT III: BAND MACHINING/CONTOURING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: VERTICAL BAND SAWS

   a. Information outline

   b. Transparency masters

      TM 1.1: Vertical band saw operations
      TM 1.2: Sample contour layouts
      TM 1.3: Selecting saw speeds

   c. Job sheet

      JS 1.1: Saw an internal contour

E. Unit test

F. Answers to unit test

REFERENCES

A. Books/manuals

1. "DoAll Contour Milling Machines" (Operator's Instruction Manual). Minneapolis: Continental Machines, Inc., 1943.

2. Olivo, C. Thomas. Advanced Machine Tool Technology. North Scituate, MA: Breton Publishers, 1982.

3. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested supplemental materials

1. Introduction to the Vertical Band Saw (MS-84-325) (video). Sedalia, MO: State Fair Community College, 1984. (Available for purchase from SFCC; available for loan from Missouri Vocational Resource Center, phone 800/392-7217 or 314/882-9610)

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT III: BAND MACHINING/CONTOURING

LESSON 1: VERTICAL BAND SAWS

I. Vertical band saw operations **(TM 1.1)**

A. Contouring

1. Internal contouring cuts interior curves and shapes.

2. External contouring cuts outer curves and shapes.

B. Other operations

1. Cutoff sawing cuts stock to length or other straight cuts.

2. Notching cuts notches and slots in workpieces.

3. Band filing and polishing are finishing operations which use a band file. They are especially used in die making.

4. Friction sawing refers to a high-speed sawing operation which actually softens the material by the heat generated by friction between the blade and workpiece.

II. Selecting a blade for contour sawing

A. A raker set is recommended for contouring.

B. Select width based upon minimum radius it will cut.

Blade width	Minimum radius
1/16	square
3/32	1/16
1/8	1/8
3/16	5/16
1/4	5/8
5/16	1
3/8	1-7/16
1/2	2-1/2

C. Lay out work for contour sawing. **(TM 1.2)**

1. Allow material for saw kerf.

2. Drill holes to match path of saw.

3. Drill holes to permit saw to turn corners to clear waste from the cut.

4. Avoid a layout which requires backing the blade out of a saw kerf, which can cause the blade to come off the wheels.

III. Procedure for cutting external contours

A. Layout the shape on the workpiece. Drill any holes necessary to provide relief or permit the saw blade to turn.

B. Select the appropriate saw blade based upon the smallest radius to be cut. Change the blade if necessary.

C. Use the job selector chart to determine the best cutting speed; set accordingly.

D. Lower the saw guide until it is within 1/4-3/16" of the top of the workpiece.

E. Turn on the saw. Bring the stock into contact with the blade. Slowly feed the workpiece into the blade. Follow the line. Be sure to cut on the proper side of the line or the workpiece might be cut undersized.

CAUTION: Keep fingers clear of moving saw blade at all times.

F. Cut straight lines first. Save sharp curves until last--they are more easily cut when waste material has been removed first.

G. Deburr workpiece.

IV. Procedure for cutting internal contours

A. Lay out the shape on the workpiece. Drill any holes that are necessary to provide relief or permit the saw blade to turn.

B. Select suitable saw blade based upon the smallest radius to be cut.

C. Break the blade. Insert into hole in workpiece and re-weld. Mount blade on saw with workpiece on the table.

D. Use the job selector chart to determine the best cutting speed; set accordingly. **(TM 1.3)**

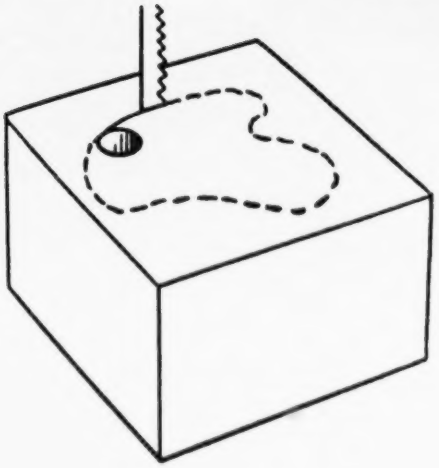
E. Lower the saw guide until it is within 1/4-3/16" of the top of the workpiece.

F. Turn on the saw. Bring the stock into contact with the blade. Slowly feed the workpiece into the blade. Follow the line. Be sure to cut on the proper side of the line or the workpiece might be cut undersized.

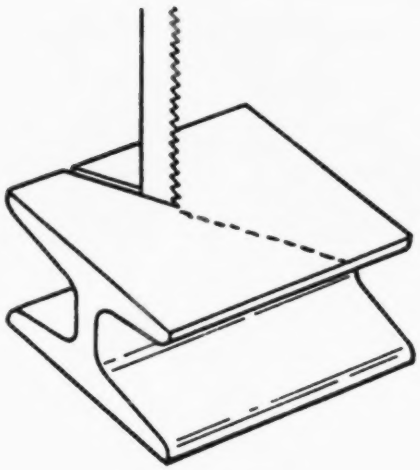
CAUTION: Keep fingers clear of moving saw blade at all times.

G. Break blade to separate from workpiece. Deburr workpiece. Return blade to storage.

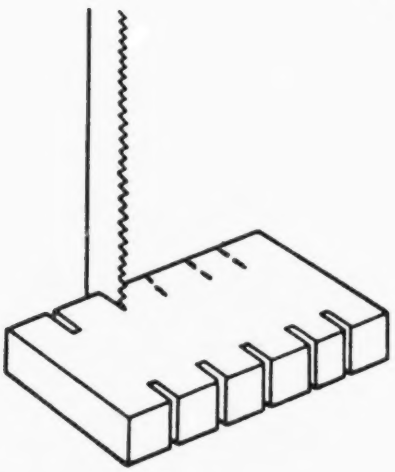
VERTICAL BAND SAW OPERATIONS



Internal contouring



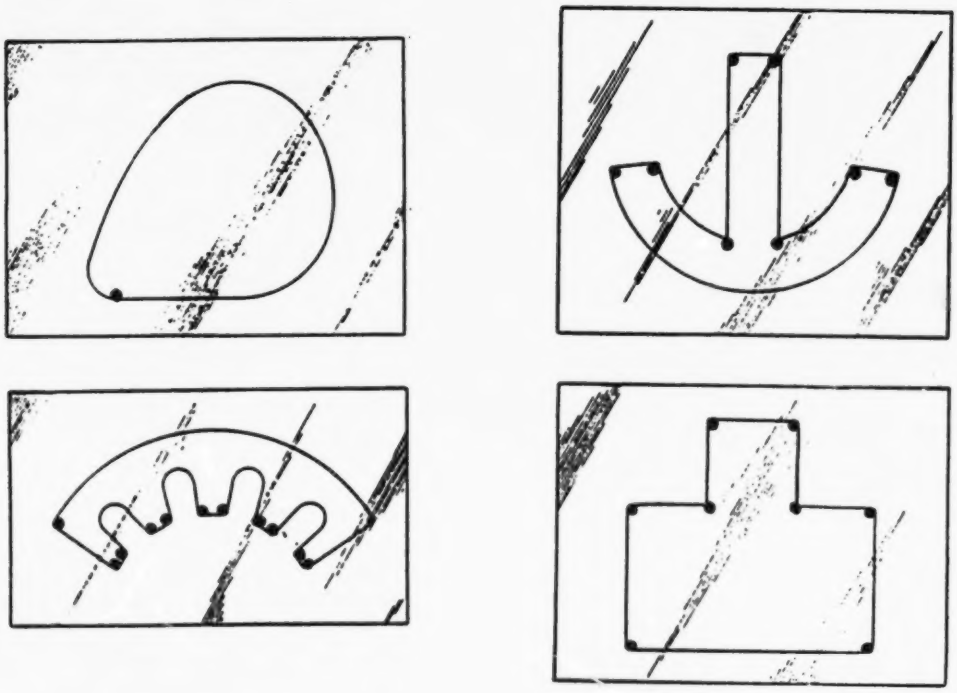
Cut-off sawing



Notching

Credit: Olivo, C. Thomas. Advanced Machine Tool Technology. North Scituate, Mass.: Breton Publishers, 1982, pg. 391.

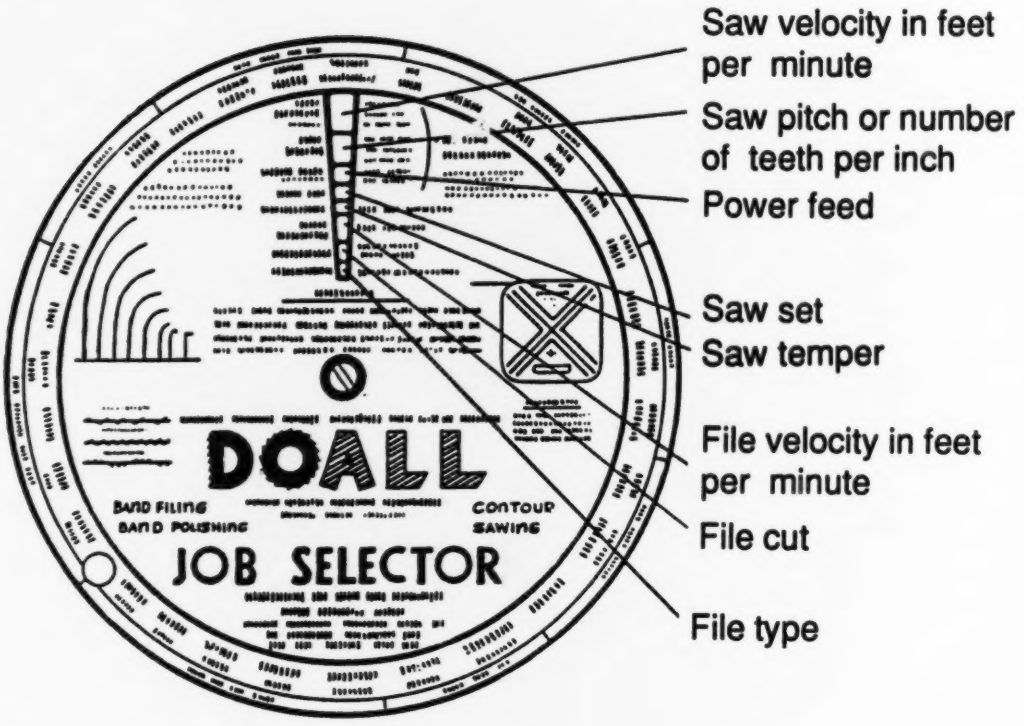
SAMPLE CONTOUR LAYOUTS



Note the hole locations for inserting the saw blade and turning corners.

Credit: "DoAll Contour Milling Machines" (Operator's Instruction Manual). Minneapolis: Continental Machines, Inc., 1943, pg. 20.

SELECTING SAW SPEEDS



This dial, usually mounted on the upper door of the machine, gives complete sawing and filing information for about 55 different materials.

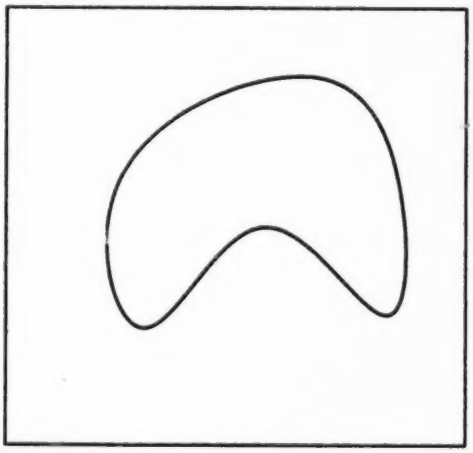
Credit: "DoAll Contour Milling Machines" (Operator's Instruction Manual). Minneapolis: Continental Machines, Inc., 1943, pg. 13.

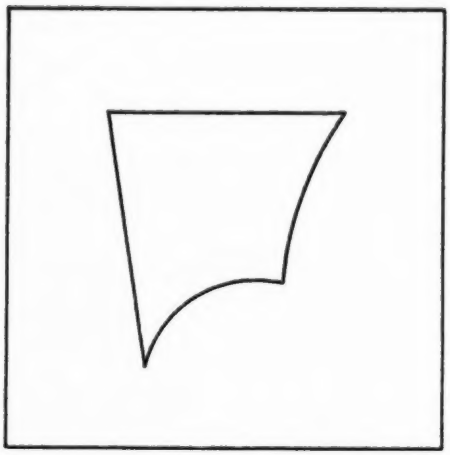
SAW AN INTERNAL CONTOUR

Equipment:

Layout tools
- Divider
- Straight edge
- Layout dye
- Scriber
- Combination set

Drill press and twist drill set
Selection of band saw blades
File or deburring tool
Metal snips
Butt welder





Procedure:	Evaluation 3	2	1	N
1. Lubricate machine per manufacturer's instructions.	—	—	—	—
2. Layout the shape on the workpiece. Drill holes as indicated to provide relief and permit the saw blade to turn.	—	—	—	—
3. Select the appropriate saw blade based upon the smallest radius to be cut.	—	—	—	—
4. Break blade. Insert into hole in workpiece and re-weld. Mount blade on saw with workpiece on table.	—	—	—	—
NOTE: Refer to Unit I of this module for review of welding procedure.				
5. Use the job selector chart to determine best cutting speed and set accordingly.	—	—	—	—

6.	Lower the saw guide until it is within 1/4-3/16" of the top of the workpiece.	—	—	—	—
7.	Turn on the saw. Bring stock into contact with the blade. Slowly feed the workpiece into the blade. Follow the line. Be sure to cut on the proper side of the line or the workpiece might be cut undersized. **CAUTION:** Keep fingers clear of moving saw blade at all times.	—	—	—	—
8.	Break blade to separate from workpiece. Deburr workpiece. Return blade to storage.	—	—	—	—
	Average of evaluations above*	—	—	—	—

*This average is the student's final evaluation for competencies G9 and G10. It is also the final third of the evaluation for competencies G1, G2 and G5.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT III: BAND MACHINING/CONTOURING

UNIT TEST

Select the option which best answers the question or completes the statement.

____ 1. Which of the following operations is <u>not</u> well-suited to the vertical band saw?

a. Friction sawing
b. Internal contouring
c. External contouring
d. Slotting
e. None of the above

____ 2. Which of the sawing operations below makes use of heat generated between the blade and the workpiece?

a. Friction sawing
b. Internal contouring
c. External contouring
d. Slotting
e. None of the above

____ 3. Which is <u>not</u> a consideration when laying out a workpiece for contour sawing?

a. Provide holes for blade relief
b. Saw kerf allowance
c. Avoid backing out the blade
d. Blade pitch
e. None of the above

____ 4. When contour sawing, why is it important to cut on the correct side of the line?

a. The workpiece might be cut undersized.
b. The blade can break.
c. The operator might become injured.
d. A radius cut can result.
e. None of the above

____ 5. Which operation requires that the blade be broken and rewelded?

a. Friction sawing
b. Internal contouring
c. External contouring
d. Slotting
e. None of the above

ANSWERS TO UNIT TEST

1. e
2. a
3. d (G10)
4. a (G10)
5. b (G10)

MODULE: POWER SAW AND DRILL PRESS OPERATION
UNIT IV: DRILL PRESS TYPES AND SAFETY

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify types and parts of drilling machines, hazardous conditions and safety rules for operating drilling machines. This knowledge will be evidenced by achieving a specified score on the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Identify general drilling machine information.

1.2 Identify the major types of drilling machines and their uses.

1.3 Identify the major parts of a sensitive drill press.

1.4 Identify the major parts of a radial drill press. (competency H4)

2.1 Describe clothing requirements when working with a drill press.

2.2 Identify machine operation safety rules.

2.3 Identify shop safety guidelines. (competency H1)

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT IV: DRILL PRESS TYPES AND SAFETY

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: DRILL PRESS TERMS AND TYPES

   a. Information outline

   b. Transparency master

      TM 1.1: Types of drill presses

   c. Handouts

      HO 1.1: Parts of the sensitive drill press
      HO 1.2: Parts of the radial drill press

   d. Assignment sheet

      AS 1.1: Parts and functions of drill presses

   e. Answers to assignment sheet

2. Lesson 2: DRILL PRESS SAFETY

   a. Information outline

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Baril, Richard. Modern Machining Technology. Albany, NY: Delmar Publishers, Inc., 1987.

2. Kibbe, R. R. and J. E. Neely. Machine Tool Practices. New York: John Wiley and Sons, 1979.

3. Krar, S. F., J. W. Oswald and J. E. St. Amand. Technology of Machine Tools. 3rd ed. Toronto: McGraw-Hill, 1984.

4. Olivo, C. Thomas. Machine Tool Technology and Manufacturing Processes. Albany, NY: C. Thomas Olivo Associates, 1987.

B. Curriculum guides

1. Alabama Performance-Based Instruction Guide for Machine Shop Teachers. Montgomery, AL: State Department of Education, Division of Vocational Education Services, 1983.

2. Hardman, William E. Basic Machine Shop. Textbook Series. Washington, DC: National Tool, Die & Precision Machining Association, 1980.

3. Machinist. Frankfort, KY: Vocational-Technical Education Consortium of States, 1982.

4. Dunn, James. Machine Shop I. Stillwater: Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1981.

5. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Show examples of drilling machines available in the shop.

2. Give students examples of the types of injuries that can occur in drilling operations.

B. Suggested supplemental materials

1. Publications

   a. Oberg, Erik; Franklin D. Jones; Holbrook L. Horton. Machinery's Handbook. 22nd ed. New York: Industrial Press Inc., 1984.

   b. Other materials related to specific machines can be obtained from manufacturers.

2. Audiovisual

   a. Drill Press Types, Parts, and Safety (MS-84-330) (video). Sedalia, MO: State Fair Community College, 1984. (Available for purchase from SFCC; available for loan from Missouri Vocational Resource Center, phone 800/392-7217 or 314/882-9610)

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT IV: DRILL PRESS TYPES AND SAFETY

LESSON 1: DRILL PRESS TERMS AND TYPES

I. General

A. There are specialized drilling machines which can produce very small, large or deep holes.

1. Some have multiple spindles or are equipped with turret heads.

2. Although some of these machines more closely resemble lathes than drill presses, their theory of operation is almost the same as that of the three basic types of drill presses.

B. The drill press is primarily used for drilling holes or modifying a drilled hole.

1. The cutting tool is rotated and the part remains stationary.

2. The tool is fed into the workpiece either manually or by using an automatic feed.

C. Drill press size is determined by measuring from the center of the spindle to the column. Vertically, it is the maximum distance from the table at its lowermost position to the head at its uppermost position.

II. Basic types of drill presses **(TM 1.1)**

A. Type I--sensitive drill press

1. Most common drill press

2. Usually driven by a stepped pulley and belt or a variable speed belt drive

3. Used for light-duty drilling (usually has a 1/2" to 1" maximum drilling capacity)

4. Usually hand fed

5. May be bench- or floor-mounted

B. Type II--upright drill press

1. Similar to the sensitive drill press but made for much heavier work (2" or more in diameter)

2. Usually more powerful and gear-driven

3. Equipped with adjustable power feed and manual

4. Table raised and lowered by a mechanism

C. Type III--radial drill press

1. Most versatile of all drill presses

2. Equipped with adjustable power feed and manual

3. Adjustable arm and head that can be locked in place to avoid repositioning the workpiece

4. Particularly useful on very large or heavy parts which would be too heavy to be repositioned easily

5. Used for very small to very large drilling operations

III. Major parts of a sensitive drill press **(HO 1.1)**

A. Base--bottom of the machine which contacts the floor and supports the rest of the drill press

B. Column--round vertical support for the table and drill head (attached to the base)

C. Table--provides a flat surface on which to mount the workpiece or workholding devices

D. Table lock--prevents the table from moving after it has been positioned

E. Head (or drill head)--machine part which does the actual work

1. Depth stop--mechanical stop used to limit the spindle movement to a specified distance

2. Guard--provides protection from moving parts

3. Motor--primary driving force to turn the tool

4. Quill--housing for the spindle which allows vertical movement of the spindle

5. Quill feed handle--used to provide downward force for the cutting tool

6. Quill lock--device which locks the spindle in place

7. Quill return spring--retracts the quill and spindle to the home position

8. Speed selector--gears, step pulleys or variable-speed drive used to change the rotational speed of the tool

9. Spindle--rotating part which holds and drives the tool

10. Switch--used to start and stop the motor

IV. Major parts of the radial drill press **(HO 1.2)**

A. Base--bottom of the machine which contacts the floor and supports the rest of the drill press

B. Column--round vertical support for the table and arm (attached to the base)

C. Elevating screw--mechanism which raises and lowers the arm and head

D. Arm--gives the head radial movement about the column

E. Spindle--rotating part which holds and drives the tool

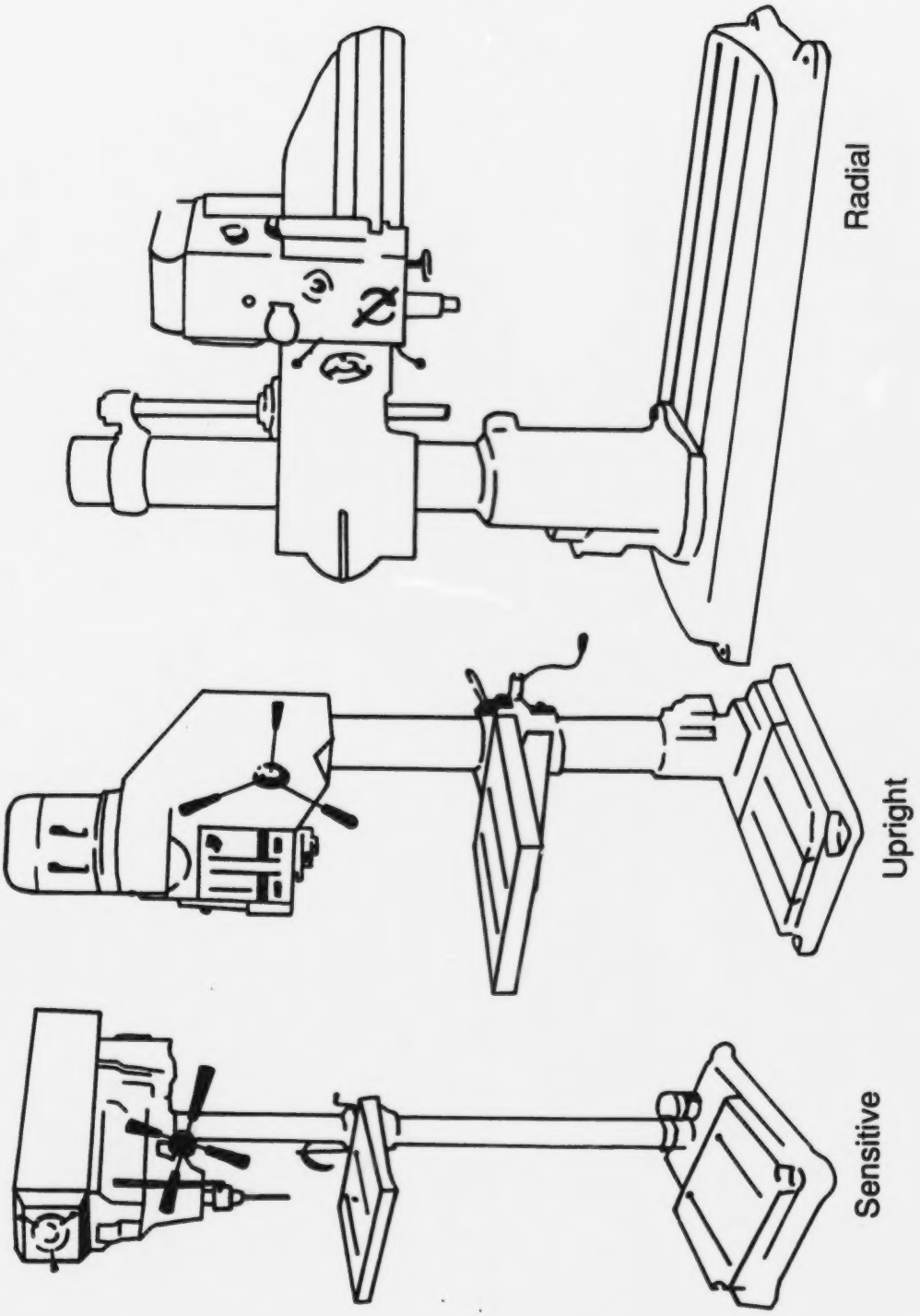
F. Drill head--part with horizontal positioning which does the actual work

1. Speed selectors change spindle speeds.

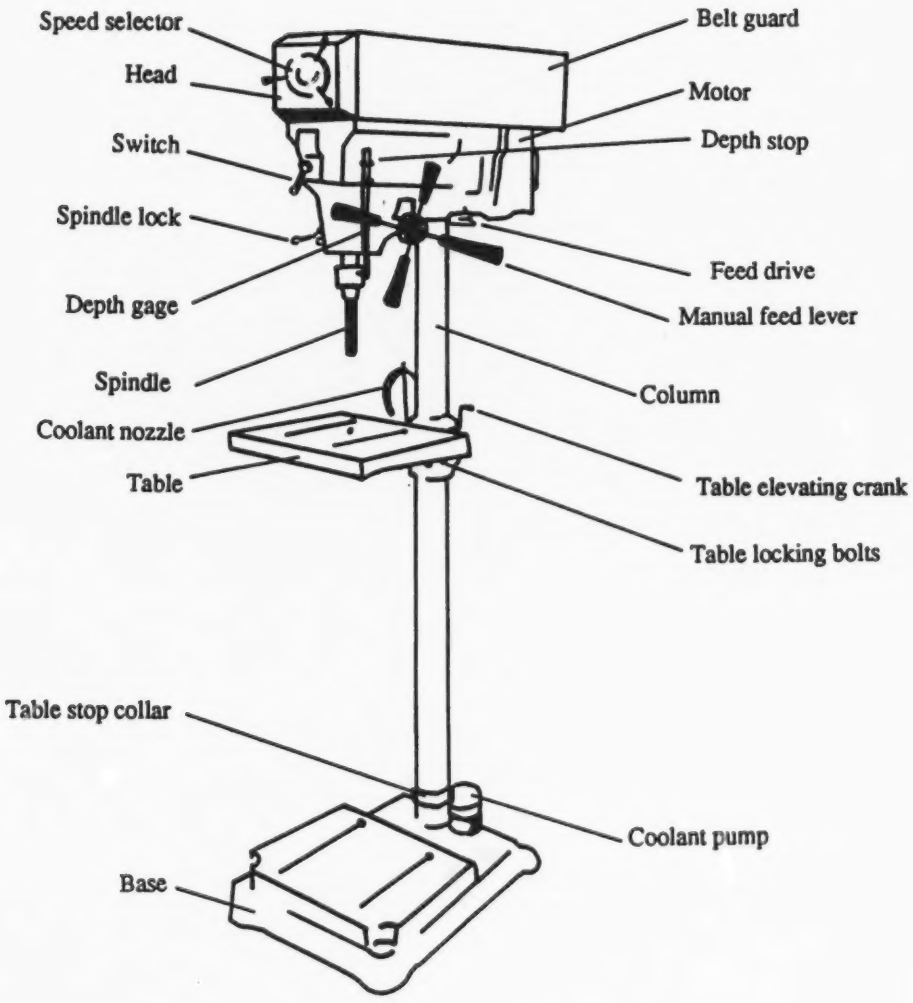
2. The spindle reverse lever changes rotational direction (and corresponding spindle feed).

3. The feed change lever provides for different spindle feed rates.

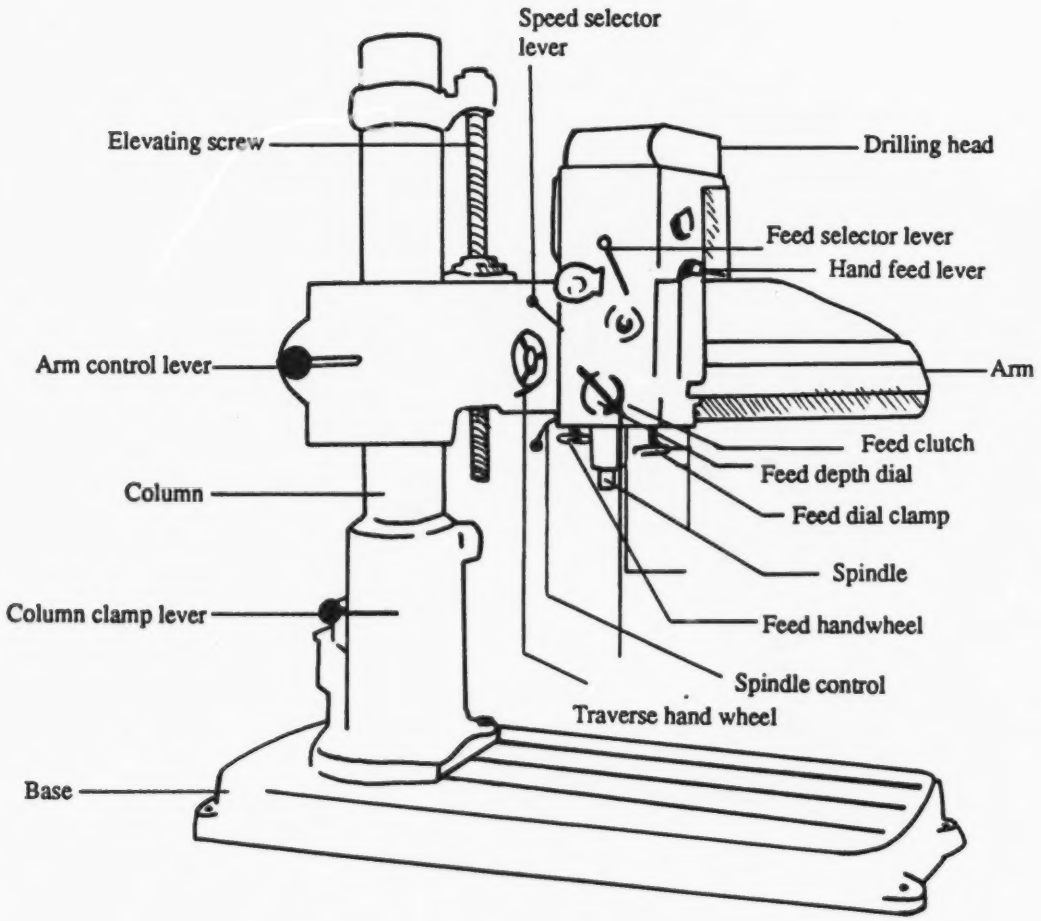
TYPES OF DRILL PRESSES



PARTS OF THE SENSITIVE DRILL PRESS



PARTS OF THE RADIAL DRILL PRESS



PARTS AND FUNCTIONS OF DRILL PRESSES

Match the functions of drill press parts with part names by placing the correct letters in the blank spaces.

____ 1. Bottom of the machine which contacts the floor and supports the rest of the machine

____ 2. Round vertical support attached to the base

____ 3. Flat surface on which the work or work-holding devices are attached

____ 4. Part of the machine which does the actual work and houses the moving parts

____ 5. Provides the force to run the machine

____ 6. Prevents the table from moving after it has been positioned

____ 7. Pulleys or gears used to change the rotational speed of the tool

____ 8. Used to manually give the tool downward force

____ 9. Rotating part which holds and drives the tool

____ 10. Housing for the spindle which allows for vertical movement

____ 11. Device which holds the spindle at a specified position

____ 12. Limits the movement of the spindle

____ 13. Provides the radial movement of the head around the column

____ 14. Used to raise and lower the arm and head

a. Base
b. Column
c. Depth stop
d. Drill head
e. Elevating screw
ab. Motor
ac. Quill
ad. Quill feed handle
ae. Quill lock
bc. Arm
bd. Speed selector
be. Spindle
cd. Table lock
ce. Table

ANSWERS TO AS 1.1

1. a
2. b
3. ce
4. d
5. ab
6. cd
7. bd
8. ad
9. be
10. ac
11. ae
12. c
13. bc
14. e

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT IV: DRILL PRESS TYPES AND SAFETY

LESSON 2: DRILL PRESS SAFETY

I. Clothing requirements

A. Proper eye protection must be worn at all times in the machine shop.

B. Dress properly without loose clothing, long sleeves, ties, jewelry, watches, rings or gloves.

II. Machine operation

A. Always use a clamp, vise or stop to prevent the work from spinning. Never attempt to hold the work with your hands.

B. Never adjust the work unless the machine is stopped.

C. Never adjust speeds unless the machine is stopped, except on variable speed machines.

D. Keep clear of moving parts.

E. When the drill begins to break through the material, ease up on the pressure and let the drill bit ease through to prevent the drill bit from grabbing.

F. Never leave the chuck key in the chuck. When your hand leaves the chuck, make sure the key comes with it.

G. Never attempt to stop the chuck with your hand; let it stop on its own.

H. Never attempt to stop work which might be caught on the drill.

I. Never clean the spindle taper with the machine running.

J. Ease up on the drilling pressure occasionally to break the chip. This will prevent cuts and make clean-up easier.

K. Always use a brush to remove chips--not air or your fingers. Remove chips only when the machine is stopped.

L. When removing tapered shank drill bits from the spindle, always put a board under the bit to protect the drill bit, table and your toes.

M. When moving the head or table on a sensitive drill press, make sure that safety collars are positioned near the head or table to prevent them from dropping unexpectedly.

N. The drill bit should be properly sharpened and operated at the correct speed.

O. Never leave a machine that is running.

III. Shop safety

A. Obtain permission from the instructor before operating any machine.

B. Only one person should operate a machine at a time.

C. Always remove burrs from a drilled hole with a file or scraper as soon as it is removed from the machine.

D. Keep the floor and work area clean. Wipe up any oil immediately.

E. Place any unnecessary tools or articles on an adjacent work table, not on the drill press table.

F. Get help when lifting heavy holding devices or workpieces.

G. When you have completed your work, stop the machine and clean the work area.

H. Wipe drill bits and other tools clean; lightly oil before returning them.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT IV: DRILL PRESS TYPES AND SAFETY

UNIT TEST

Mark the answer sheet with an "a" if the statement is true and a "b" if the statement is false.

____ 1. Proper eye protection must be worn at all times in the machine shop.

____ 2. To prevent the workpiece from spinning, you can use your hands to hold the work.

____ 3. The workpiece can be adjusted with the drill running.

____ 4. A variable-speed drive is the only type which can be changed with the spindle turning.

____ 5. Burrs and edges which are left on the workpiece affect neither the safety nor the accuracy of the piece.

____ 6. Keep clothing, hair, arms and legs clear of any moving parts.

____ 7. To prevent the drill bit from grabbing when it begins to break through the material, the operator should ease up on feed pressure.

____ 8. The chuck key can be left in the drill chuck so that it is easy to use the next time it's needed.

____ 9. Never attempt to stop the chuck with your hand. Let the spindle stop on its own.

____ 10. If work is caught on the rotating drill, it can be removed only if the machine is stopped.

____ 11. Never clean the spindle taper with the machine running.

____ 12. Keep the floor and work area clean and free from oil and chips.

____ 13. Spilled or splattered oil should be wiped up immediately.

____ 14. The drill-press table should not have any unnecessary tools, rags or other articles on it.

____ 15. Some workpieces and holding devices are heavy. When the operator feels uncomfortable about handling them, he or she should ask for assistance.

____ 16. Rings, ties and long sleeves may be worn while operating the drill press.

____ 17. To protect the operator from cuts, ease up on the drilling pressure occasionally to break the chips.

____ 18. If the drill is stopped, chips can be removed with your fingers.

____ 19. The cutting tool should be properly sharpened and operated at the proper speed for the material.

____ 20. When removing tapered shank tool bits from the spindle, a board should be placed under the tool.

____ 21. Safety collars on the sensitive drill press are designed to protect the drill press, not the operator.

____ 22. Instructor permission to operate the machine is not usually necessary.

____ 23. A brush, not your fingers or air, can be used to clean chips.

____ 24. When your work is finished and it is the beginning of another work shift, there is no need to clean the machine because someone else may use it.

____ 25. Only one person should operate a machine at a time.

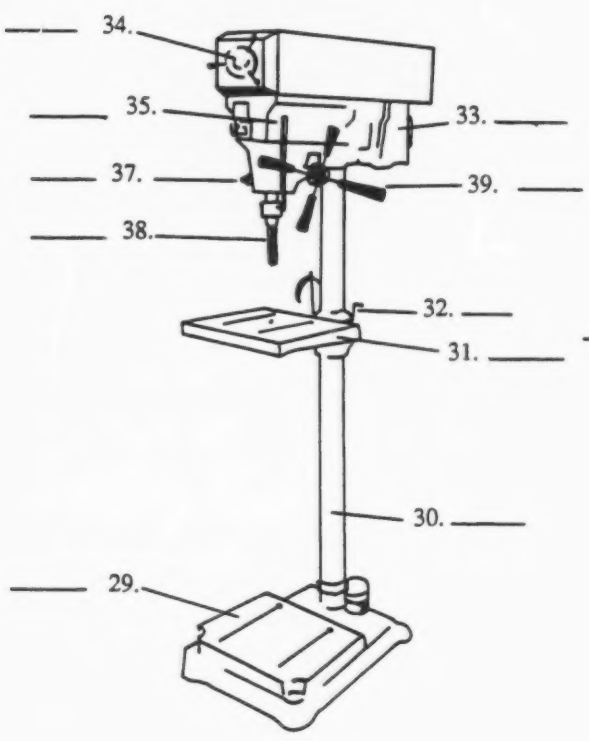
____ 26. A machine can be left running as long as the operator plans to come back to it soon.

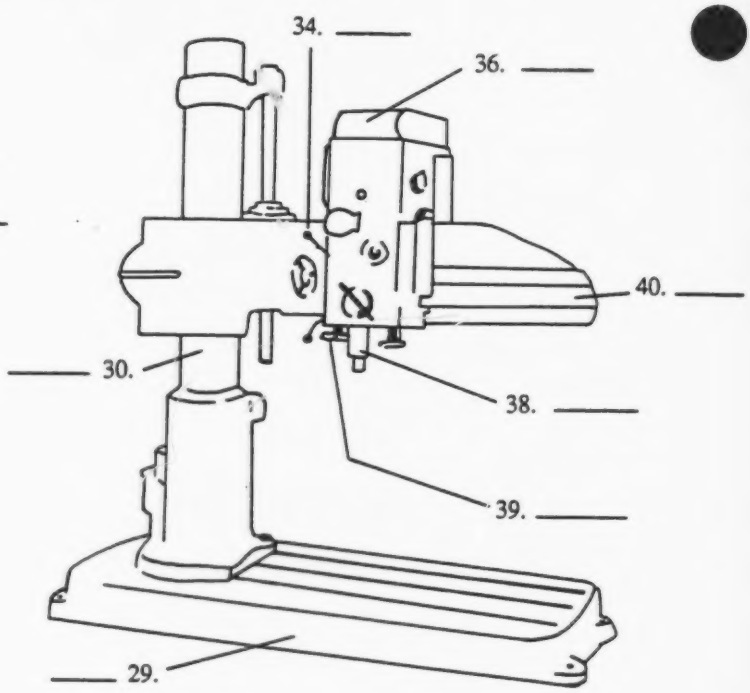
____ 27. When work has been completed, stop the machine and clean the work area.

____ 28. When storing tool bits in their proper place, wipe them clean and then lightly oil them.

Identify the machines below by matching the appropriate letter to the part. Answers may be used more than once.

a.	Arm	ad.	Motor
b.	Base	ae.	Quill
c.	Column	bc.	Speed selector
d.	Depth stop	bd.	Spindle
e.	Drill head	be.	Spindle lock
ab.	Elevating screw	cd.	Table
ac.	Manual feed	ce.	Table elevating crank





Select the option which best answers the question or completes the statement.

___ 41. How is drill press size determined?

a. By measuring from the center of the spindle to the column
b. Vertically by the maximum distance from the base's bottom to the head at its uppermost position
c. By measuring from back of the column to the front of the spindle
d. By measuring from the floor to the top of the drilling head
e. By the maximum length drill it will hold

___ 42. Which type of drill press is the most common?

a. Type I
b. Type II
c. Type III
d. Type IV
e. Type V

___ 43. Which type of drill press is the most versatile?

a. Sensitive
b. Upright
c. Radial
d. Type II
e. Multiple spindle

___ 44. For light-duty drilling of a 1/2" hole, which is the least expensive and most appropriate kind of drill to use?

a. Sensitive
b. Upright
c. Radial
d. Type II
e. Multiple spindle

NOTE: Completion of this test to specified score is the student's final evaluation for competencies H1 and H4.

ANSWERS TO UNIT TEST

1.	a	(H1)	24.	b	(H1)
2.	b	(H1)	25.	a	(H1)
3.	b	(H1)	26.	b	(H1)
4.	a	(H1)	27.	a	(H1)
5.	b	(H1)	28.	a	(H1)
6.	a	(H1)	29.	b	(H4)
7.	a	(H1)	30.	c	(H4)
8.	b	(H1)	31.	cd	(H4)
9.	a	(H1)	32.	ce	(H4)
10.	a	(H1)	33.	ad	(H4)
11.	a	(H1)	34.	bc	(H4)
12.	a	(H1)	35.	d	(H4)
13.	a	(H1)	36.	e	(H4)
14.	a	(H1)	37.	be	(H4)
15.	a	(H1)	38.	bd	(H4)
16.	b	(H1)	39.	ac	(H4)
17.	a	(H1)	40.	a	(H4)
18.	b	(H1)	41.	a	(H4)
19.	a	(H1)	42.	a	(H4)
20.	a	(H1)	43.	c	(H4)
21.	b	(H1)	44.	a	(H4)
22.	b	(H1)			
23.	a	(H1)			

MODULE: POWER SAW AND DRILL PRESS OPERATION
UNIT V: DRILL PRESS WORK-HOLDING DEVICES

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify types of work-holding devices which are commonly used on the drill press. This knowledge will be evidenced by achieving a specified score on the job sheet and unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Match drill press work-holding devices with descriptions or functions.

1.2 Identify the main types of work-holding devices.

1.3 Describe a typical set-up for drilling in round stock. (competencies H3 and H13, JS 1.1 and 1.2)

1.4 Determine cutting tool variables prior to use. (competency H5)

1.5 Drill a hole using a drill jig. (competency H7 and H15, JS 1.1)

1.6 Mount and drill round stock using a V-block. (competency H13, JS 1.2)

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT V: DRILL PRESS WORK-HOLDING DEVICES

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plan

1. Lesson 1: TERMS AND TYPES OF WORK-HOLDING DEVICES

   a. Information outline

   b. Transparency master

      TM 1.1: Drill jig and bushings

   c. Handout

      HO 1.1: Drill jigs

   d. Job sheets

      JS 1.1: Drill a hole using drill jig
      JS 1.2: Mount and drill round stock using a V-block

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Audels Machinist Library: Basic Machine Shop Practices. 1st ed. New York: T. Audel and Co., 1968.

2. Baril, Richard. Modern Machining Technology. Albany, NY: Delmar Publishers, Inc., 1987.

3. Kibbe, R. R. and J. E. Neely. Machine Tool Practices. New York: John Wiley and Sons, 1979.

4. Krar, S. F., J. W. Oswald and J. E. St. Amand. Technology of Machine Tools. 3rd ed. Toronto: McGraw-Hill, 1984.

5. Olivo, C. Thomas. Machine Tool Technology and Manufacturing Processes. Albany, NY: C. Thomas Olivo Associates, 1987.

6. Porter, Lawshe and Lascoe. Machine Shop Operations and Setups. Chicago: American Technical Society, 1955.

B. Curriculum guides

1. Alabama Performance-Based Instruction Guide for Machine Shop Teachers. Montgomery, AL: State Department of Education, Division of Vocational Education Services, 1983.

2. Hardman, William E. Basic Machine Shop. Textbook Series. Washington, DC: National Tool, Die & Precision Machining Association, 1980.

3. Machinist. Frankfort, KY: Vocational-Technical Education Consortium of States, 1982.

4. Dunn, James. Machine Shop I. Stillwater: Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1981.

5. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. In evaluating students on JS 1.1 for competency H7 (Select and apply cutting fluids), refer to information presented in the Lathe module and to manufacturer specifications.

B. Suggested student activities

1. Show examples of drilling machine work holders available in the shop to the students.

C. Suggested supplemental materials

1. Publications

a. Audels Machinist Library: Basic Machine Shop Practices. 1st ed. New York: T. Audel and Co., 1968.

b. Oberg, Erik; Franklin D. Jones; Holbrook L. Horton. Machinery's Handbook. 22nd ed. New York: Industrial Press Inc., 1984.

c. Other materials related to specific machines can be obtained from manufacturers.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT V: DRILL PRESS WORK-HOLDING DEVICES

LESSON 1: TERMS AND TYPES OF WORK-HOLDING DEVICES

I. Terms and definitions **(TM 1.1)**

A. Parallels--rectangular pieces of metal, usually hardened and ground in matched pairs, which are used to support a workpiece away from the table

B. T-bolts--bolts with a T-shaped head which fit into the T-slots in the drill press table. These can be used to bolt the workpiece directly to the table or mount the holding device to the table.

C. Strap clamps--straps or clamps which are used to bolt work or holding devices to the table

D. Step blocks--steel blocks which are used to adjust the clamping height of the strap clamps

E. C-clamps--screw-type clamp which is used to clamp work to an angle plate or secure the work or holding device to the table

F. Angle plate--plate that is usually made from cast iron and machined to exactly 90°. It is used to hold parts at 90° to the table and is very useful when drilling holes parallel to a surface.

G. Vise--supports and holds the work on the drill press table (most common type of work-holding device in the shop)

H. V-blocks--hardened pieces of steel that are precision-ground and have a V machined in one or more sides. They are used to hold round work when a higher degree of accuracy is required.

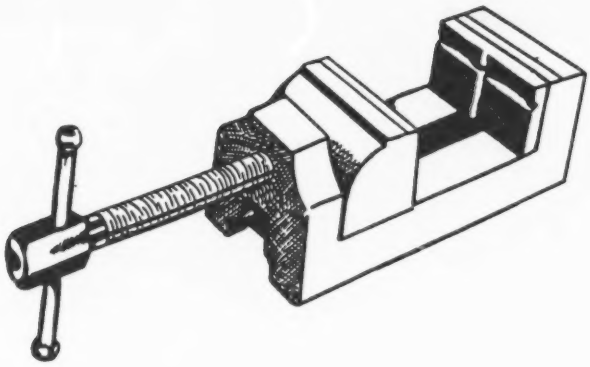
I. Jack screw or jack--supports work or aids in the clamping of a workpiece (a very simple device which uses a screw for adjustment)

J. Fixture--specially designed holding device in which the part fits down into an area which holds and positions it, fixing the relationship between the workpiece spindle and cutting tool

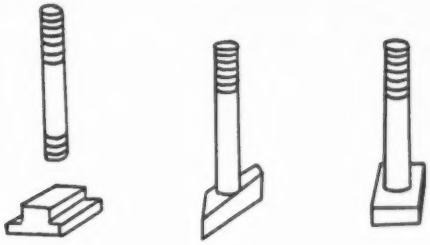
K. Drill jig--an extension of the drilling fixture. It does essentially the same thing but has bushings which guide the cutting tool to a precise location and help to produce concentric holes.

II. Types of tool holders

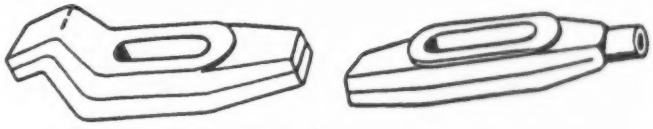
A. Vise



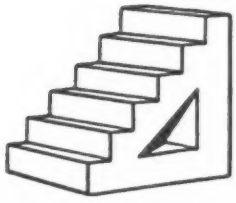
B. T-bolts



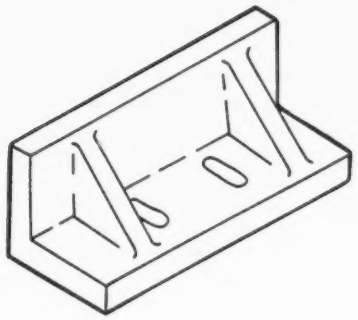
C. Strap clamps



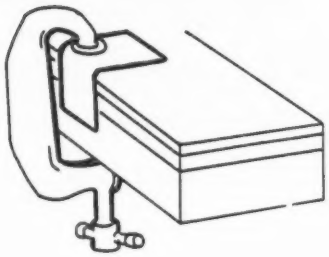
D. Step blocks



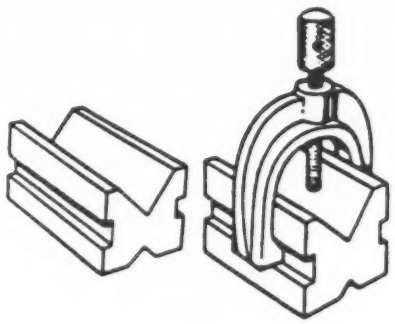
E. Angle plate



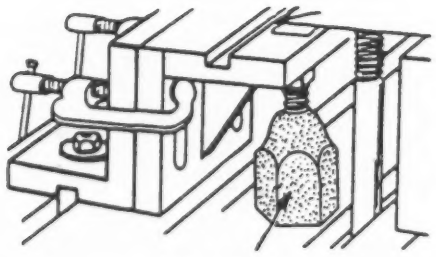
F. C-clamps



G. V-blocks

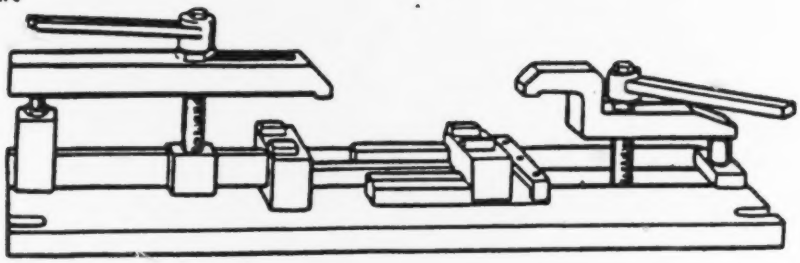


H. Jack screw

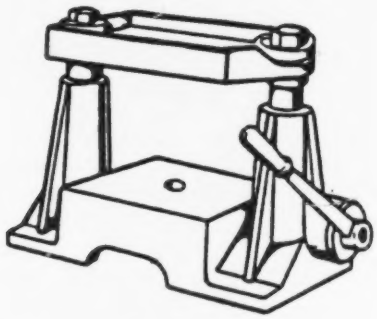


Jack screw

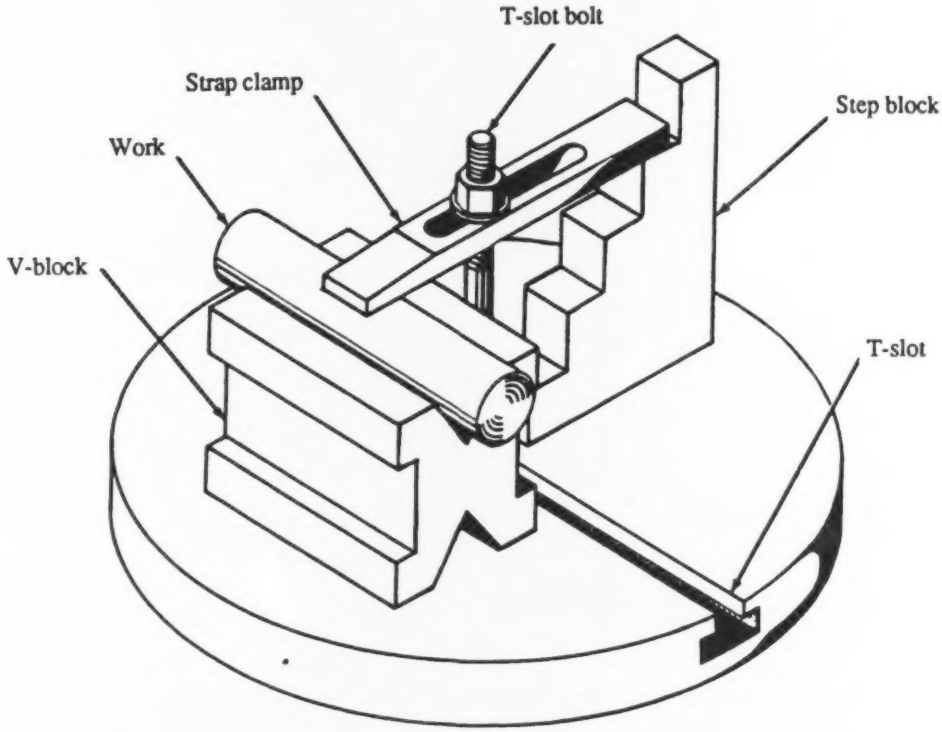
I. Drill fixture



J. Drill jig **(HO 1.1)**



III. Typical set-up in preparation for drilling in round stock



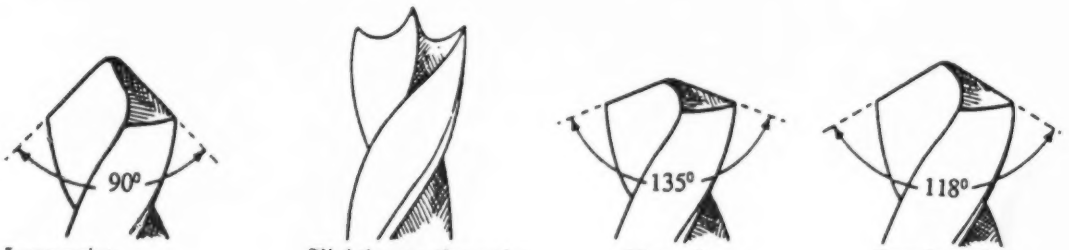
IV. Cutting tool variables

A. In most instances, the standard, commercially available 118° drill bit will do a very adequate job of producing holes.

B. Sometimes a drill bit must be modified to fit a special situation.

NOTE: Consult manufacturer specifications when drilling problem materials or if other problems occur.

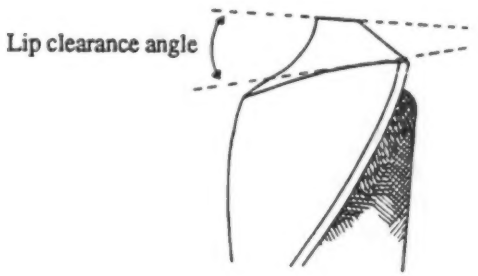
C. Choose a drill point angle based on the material being drilled.



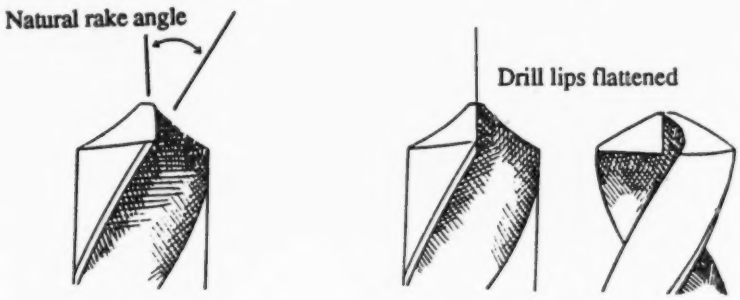
Long point (abrasive materials) | Slightly negative point (thin materials) | Flat point (tough materials) | Regular point

1. A 135° angle is effective with tough-to-drill materials.
2. The standard 118° point works well on machinable materials.
3. An acute 90° angle is used for softer materials needing more pilot area to guide the work. This point also permits faster cutting action.
4. With thin materials, a flat or slightly negative angled drill avoids the grabbing action common of other points.

D. Relief angles (usually 9-15°) allow the drill bit to feed down into the work as quickly as possible while maintaining strength behind the cutting edge.

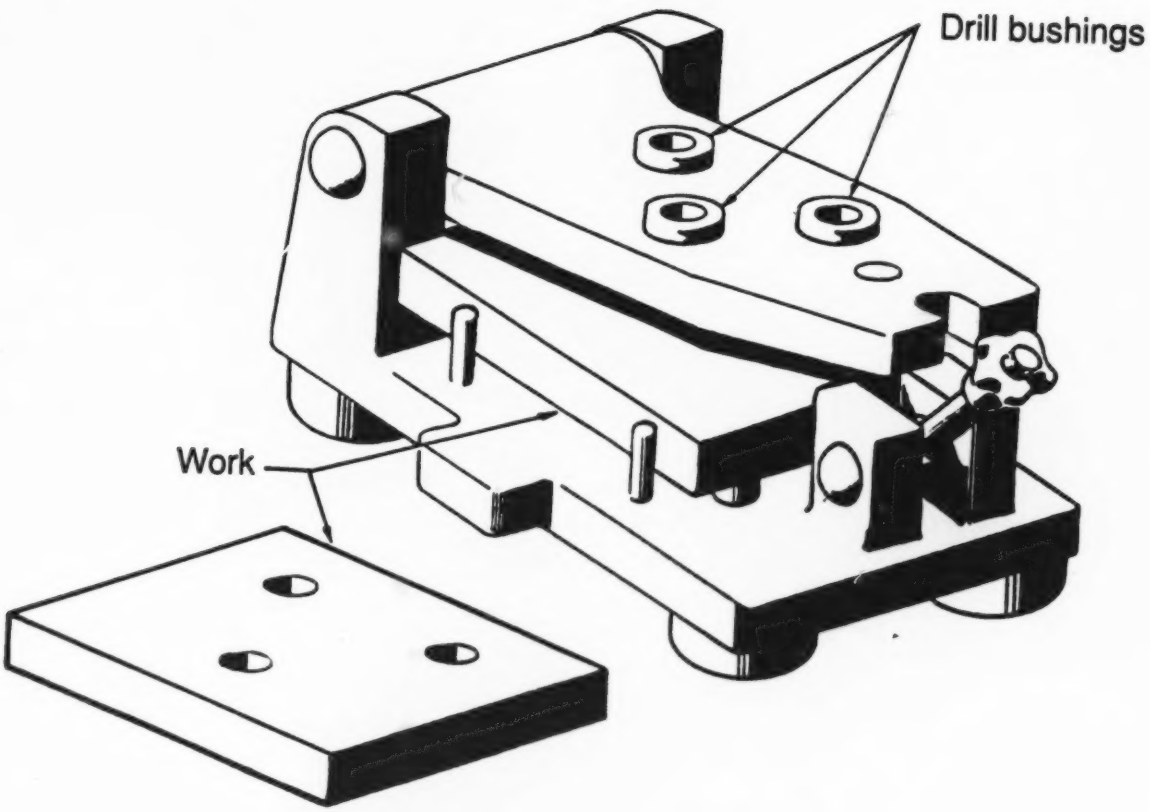


E. Rake angle is usually determined by the drill point and helix angles. In some instances, the tool will cut better and avoid pulling through the work if the cutting lips are flattened to produce a scraping action.



F. Web thinning is the process of thinning the dead center of the drill bit (which does not cut) to reduce feed pressure and resulting heat.

DRILL JIG AND BUSHINGS

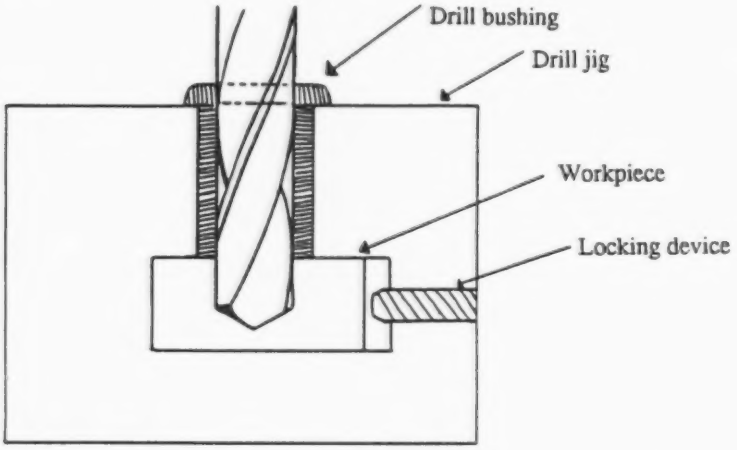


Credit: Porter, Lawshe and Lascoe. Machine Shop Operations and Setups. Chicago: American Technical Society, 1955, pg. 116.

DRILL JIGS

Drill jigs are incorporated into a work-holding fixture, which establishes datum reference points. Having the workpiece in a fixed position, the cutting tool is then guided to the desired position, maintaining the required relationship to other features of the part. The jig may float or be fixed to the table.

Drill jigs are usually constructed with replaceable guide bushings, which protect the jig from wear. These bushings can be replaced so that other hole sizes or operations can be performed on the same part, while maintaining part relationship (drilling, reaming and tapping operations).



There are many types of drill jigs, ranging from very simple to extremely complex. The function remains the same--to accurately locate the workpiece, clamp it securely and guide the tool.

DRILL A HOLE USING DRILL JIG

Equipment:

Drill press
Drill jig
Parts to be drilled
Drill bit for the proper bushing fit
Cutting oil

NOTE: When selecting a cutting fluid, refer to information presented in the Lathe module and to appropriate manufacturer specifications.

Procedure:	Evaluation 3	2	1	N
1. Place part in drill jig and check for secure fit.	—	—	—	—
2. Put drill bit in the drill chuck. Set depth stop.	—	—	—	—
3. Set rpm to proper speed for the selected drill bit.	—	—	—	—
4. Set jig directly under the drill; clamp the drill jig into position, if necessary. If several holes are to be drilled, the fixture may not be clamped down. Check set-up with instructor.	—	—	—	—
5. Lubricate the drill.	—	—	—	—
6. Turn the drill press on and feed work to the desired depth. Report procedure for additional holes in the same part.	—	—	—	—
7. Stop spindle. Remove part from jig.	—	—	—	—
8. Clean part and insert next part, if applicable, repeating process.				
9. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

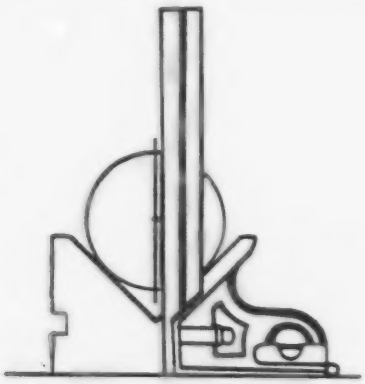
*This average is the student's partial evaluation for competencies H3 and H7 and final evaluation for competency H15: Use drill jigs and bushings.

MOUNT AND DRILL ROUND STOCK USING A V-BLOCK

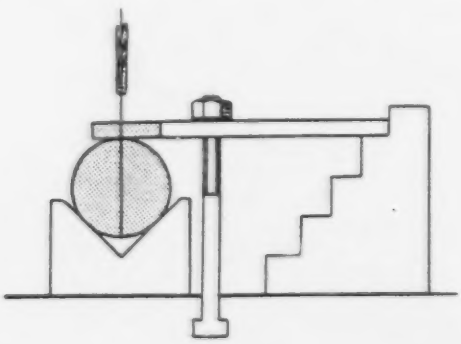
Equipment:

Drill press
Clamps
V-block
Square and center head
Center punch and hammer
Center drill and drill bit
Scribe

Procedure:	Evaluation 3	2	1	N
1. Using the center head, locate the center of the workpiece by scribing a line.	—	—	—	—
2. Using the square, measure distance back from the end; locate the hole position with the center line. Center punch the marked location.	—	—	—	—
3. With the square, align the workpiece in the V-block with the center line vertical.	—	—	—	—



4. Use the center drill to locate the center punched mark directly under the spindle; carefully clamp the work.	—	—	—	—



5.	Set the drill to the proper speed. Apply cutting fluid.	—	—	—	—
6.	Start the machine. Drill until the hole is adequately spotted to align the drill bit. Stop the machine.	—	—	—	—
7.	Remove the center drill and insert the proper drill for the job. Reset speed. Set depth stop. Apply cutting fluid.	—	—	—	—
8.	Restart the machine. Drill to desired depth.	—	—	—	—
9.	Remove the workpiece and deburr hole(s).	—	—	—	—
10.	Clean up area; return tools and materials.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is the student's final evaluation for competencies H3, H7 and H13.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT V: DRILL PRESS WORK-HOLDING DEVICES

UNIT TEST

Match work-holding devices with functions or descriptions.

___ 1. Rectangular pieces of metal used to support the workpiece away from the table

___ 2. Most common type of work-holding device in the shop. It holds and supports work on the drill press table.

___ 3. Hardened pieces of metal that are precision-ground and have a V machined into one or more of the sides; used for precise holding of round stock

___ 4. A precision iron plate used to hold work at 90° to the table

___ 5. A simple tool which uses a screw for adjustment and is used to support the work or as a clamping aid

___ 6. A screw-type device which is used to clamp work to the table or to an angle plate

___ 7. Steel blocks which are machined at several levels and are used for adjusting the height of the strap clamps

___ 8. Pieces of metal which are used to bolt work or holding devices to the table

___ 9. Fasteners which fit directly into the slots in the drill press table and are used to hold the work or a work-holding device

___ 10. Specially designed device which holds, positions and has bushings to guide the tool

___ 11. Specially designed device which holds and positions the workpiece, fixing the relationship between the spindle, cutting tool and the workpiece

a. Angle plate

b. C-clamps

c. Drill fixture

d. Drill jig

e. Jack screw

ab. Parallels

ac. Step blocks

ad. Strap clamps

ae. T-bolts

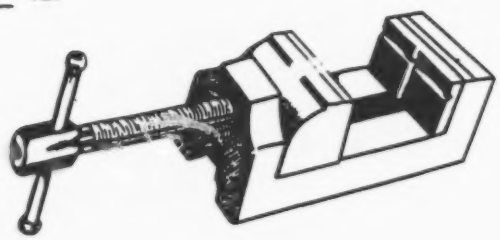
bc. V-blocks

bd. Vise

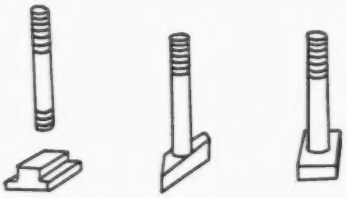
Match the following names with the illustrations shown below.

a. Angle plate
b. C-clamp
c. Drill fixture
d. Drill jig
e. Jack screw
ab. Parallels
ac. Step blocks
ad. Strap clamps
ae. T-bolts
bc. V-blocks
bd. Vise

___ 12.



___ 13.



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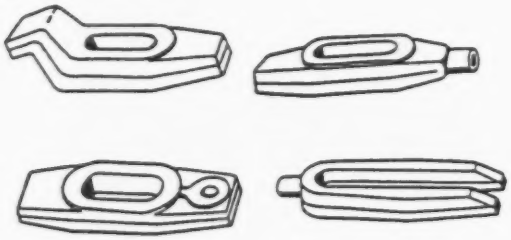

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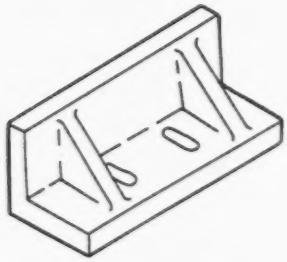
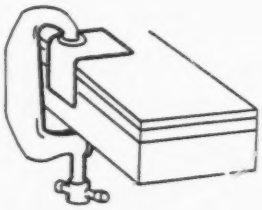
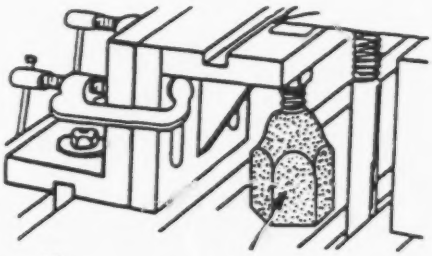


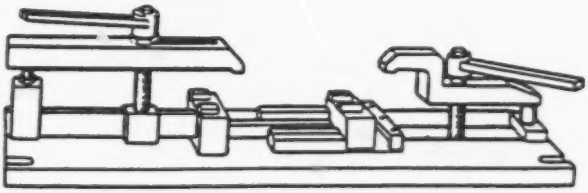
___ 16.



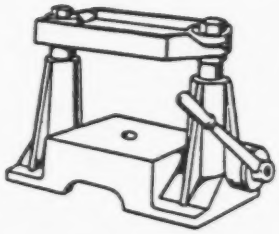
___ 17.



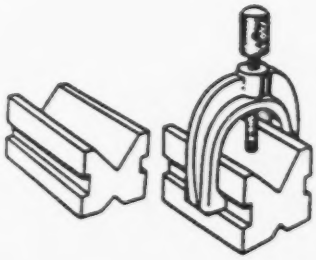
___ 18.



___ 19.



___ 20.



Select the option which best answers the question or completes the statement.

___ 21. What size angle does the general-purpose drill bit most commonly have?

a. 135°
b. 118°
c. 90°
d. 45°
e. 0°

___ 22. When drilling hard or tough material, what type of drill point is recommended?

a. More angled than general-purpose
b. Sharper
c. More rounded
d. Duller
e. Flatter

___ 23. What does relief angle allow the tool to do?

a. Feed down without rubbing
b. Figure cutting variables
c. Be used in a smaller drill
d. Drill in reverse
e. None of the above

___ 24. Flattening drill bit lips to produce a 0° rake angle gives what kind of cutting action?

a. Angular
b. Rubbing
c. Scraping
d. Scratching
e. Faster

___ 25. What does web thinning do?

a. Reduces heat and pressure required
b. Produces more heat and pressure
c. Thins the outside of the bit
d. Used on small drill bits
e. Thickens the dead center of the bit

26. List three work-holding devices that would commonly be used when setting up round stock for drilling.

a.

b.

c.

ANSWERS TO UNIT TEST

1.	ab	(H3)
2.	bd	(H3)
3.	bc	(H3)
4.	a	(H3)
5.	e	(H3)
6.	b	(H3)
7.	ac	(H3)
8.	ad	(H3)
9.	ae	(H3)
10.	d	(H3)
11.	c	(H3)
12.	bd	(H3)
13.	ae	(H3)
14.	ad	(H3)
15.	a	(H3)
16.	b	(H3)
17.	e	(H3)
18.	c	(H3)
19.	d	(H3)
20.	bc	(H3)
21.	b	(H5)
22.	e	(H5)
23.	a	(H5)
24.	c	(H5)
25.	a	(H5)

26. Any three of the following: (H13)
Step block
Strap clamp
T-slot bolt
T-slot table
V-block

MODULE: POWER SAW AND DRILL PRESS OPERATION
UNIT VI: TOOLS AND TOOL HOLDERS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify types of tool-holding devices and tools which are commonly used on the drill press. This knowledge will be evidenced by completion of the job sheets and unit test to a specified score.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Match drill press tool-holding terms with definitions or illustrations.

1.2 Identify the main types of tool-holding devices and functions.

1.3 Describe radial drill press uses. (competency H19)

2.1 Match cutting tool terms with definitions.

2.2 Identify cutting tools.

2.3 Calculate speed and feed rates using the charts provided. (competency H6, JS 2.1)

2.4 Center drill and drill a hole. (competency H8 and H9, JS 2.1)

2.5 Bore a hole. (competency H2, JS 2.2)

2.6 Ream a hole. (competency H14, JS 2.3)

2.7 Counterbore and spotface. (competency H11 and H12, JS 2.4)

2.8 Chamfer and countersink. (competency H10, JS 2.5)

2.9 Tap a hole by hand. (competency H16, JS 2.6)

2.10 Hand-grind drills on the pedestal grinder. (competency H18, JS 2.7)

2.11 Grind drill bits with a drill grinder. (competency H18, JS 2.8)

2.12 Tap a hole with a tapping attachment. (competency H17, JS 2.9)

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT VI: TOOLS AND TOOL HOLDERS

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   b. Handout

      HO 1.1: Devices for holding cutting tools

   c. Assignment sheet

      AS 1.1: Tool-holding devices

   d. Answers to assignment sheet

2. Lesson 2: CUTTING TOOL TERMS AND TYPES

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   b. Transparency master

      TM 2.1: Parts of a drilling tool

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      HO 2.1: Cutting tools and operations
      HO 2.2: Cutting speeds
      HO 2.3: Decimal equivalents: wire, letter and fractional sizes

   d. Assignment sheet

      AS 2.1: Cutting tools

   e. Answers to assignment sheet

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      JS 2.1: Center drill and drill a hole
      JS 2.2: Bore a hole
      JS 2.3: Ream a hole
      JS 2.4: Counterbore and spotface
      JS 2.5: Chamfer and countersink
      JS 2.6: Tap hole by hand

JS 2.7: Hand-grind drills on the pedestal grinder
JS 2.8: Grind drill bits using a drill grinder
JS 2.9: Tap hole with a tapping attachment

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Audels Machinist Library: Basic Machine Shop Practices. 1st ed. New York: T. Audel and Co., 1968.

2. Baril, Richard. Modern Machining Technology. Albany, NY: Delmar Publishers, Inc., 1987.

3. Kibbe, R. R. and J. E. Neely. Machine Tool Practices. New York: John Wiley and Sons, 1979.

4. Krar, S. F., and J. W. Oswald. Technology of Machine Tools. New York: McGraw-Hill, 1977.

5. Moltrecht, Karl. Machine Shop Practice. Vol. I. New York: Industrial Press Inc., 1971.

5. Olivo, C. Thomas. Machine Tool Technology and Manufacturing Processes. Albany, NY: C. Thomas Olivo Associates, 1987.

B. Curriculum guides

1. Alabama Performance-Based Instruction Guide for Machine Shop Teachers. Montgomery, AL: State Department of Education, Division of Vocational Education Services, 1983.

2. Machinist. Frankfort, KY: Vocational-Technical Education Consortium of States, 1982.

3. Dunn, James. Machine Shop I. Stillwater: Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1981.

4. Hardman, William E. Basic Machine Shop. Textbook Series. Washington, DC: National Tool, Die & Precision Machining Association, 1980.

5. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Show examples of drilling machine tool holders and tools available in the shop.

2. To prepare for calculating feeds and speeds, students can review information in the Modules 1-3 (Machine Shop Orientation and Math, Measurement and Blueprint Reading, and Bench Work and Material Science).

B. Suggested supplemental materials

1. Publications

a. Audels Machinist Library: Basic Machine Shop Practices. 1st ed. New York: T. Audel and Co., 1968.

b. Oberg, Erik; Franklin D. Jones; Holbrook L. Horton. Machinery's Handbook. 23rd ed. New York: Industrial Press Inc., 1988.

c. Other materials related to specific machines can be obtained from manufacturers.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT VI: TOOLS AND TOOL HOLDERS

LESSON 1: TOOL HOLDER TERMS AND TYPES

I. Terms and definitions

A. Drift--flat, tapered tool used for the removal of tapered shank tools from the drill

B. Drill chuck--frictional holding device for straight shank tools

C. Morse taper--type of self-holding taper commonly used on many types of machines found in the machine shop

D. Quick-change chuck--quick-change tool-holding device using balls, cams or levers to hold tools and provide driving power

E. Sleeve--device which permits the use of a tapered shank tool in the spindle of a machine that has a larger sized taper

F. Socket--tapered-shank tool-holding device which lets a machine with a small tapered spindle use a tool which has a larger taper

G. Tapered spindle--spindle bored to a taper for holding tools which are tapered to a specific size. A frictional lock is created when the tool is inserted.

H. Tapping attachment--planetary-geared system which (through a clutching system) allows rotation of the cutting tool in one direction as pressure is applied. When the pressure is reduced and return pressure is applied, the mechanism reverses the direction of the tool and backs the tool from the hole.

II. Types of tool-holding devices **(HO 1.1)**

A. Straight-shank tool holders

1. Key-type chuck or keyless chuck

2. Usually have a Morse taper and are removable from the spindle

3. Are made to hold the smaller-size tools (those which are 1/2" or smaller) because of their limited gripping power

B. Tapered-shank tool holders

1. Tapered-shank tools are inserted directly into the spindle of the drill press and provide a friction fit.

a. Increased pressure increases the wedge fit.

b. To provide a positive drive, a slotted recess on the inside of the spindle engages with the tang of the drill bit or other tool.

2. Sleeve

3. Socket

4. Drift

C. Quick-change tool holder

D. Tapping attachment

III. Radial drill press uses

A. Same operations as other drill presses (speed, feed, tools and work-holding devices)

B. Essentially the same set-up procedures as with other types of drill presses

C. Distinguishing characteristics

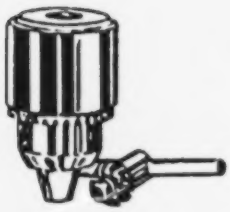
1. A radial drill press is useful for large, heavy, difficult-to-position work.

2. After part positioning, the cutting tool is positioned by rotating the arm about the column; the spindle can move in or out on the arm.

3. Both the arm and head have positioning locks.

DEVICES FOR HOLDING CUTTING TOOLS

Keyless

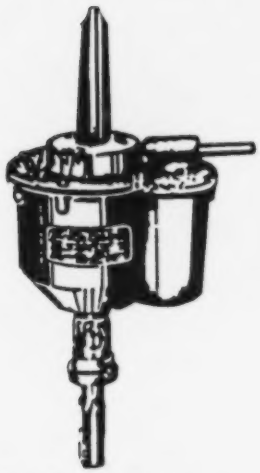


Key-type

Drill chucks

Morse taper shank adapter sleeve

Drill drift



Tapping attachment

Floating chuck

Steel sockets

Credit: Dunn, James. Machine Shop I. Stillwater: Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1981, pg. 121D. Used by permission.

TOOL-HOLDING DEVICES

Match the tool holder descriptions with names.

____ 1. A type of self-holding taper found on many of the tools in the machine shop

____ 2. A flat, tapered hand tool used for the removal of tapered-shank tools

____ 3. Planetary-geared system which (through a clutching system) allows rotation of the tool in one direction as pressure is applied

____ 4. A frictional holding device for straight-shank tools

____ 5. Device which permits the use of a tapered-shank tool in a spindle which has a larger taper size than the tool

____ 6. Adaptive device which allows the use of a larger tapered-shank tool in a spindle with a smaller taper

____ 7. A tapered bore in the spindle of a machine which allows the use of taper-shank tooling

____ 8. Device which allows for rapid removal and installation of tools in the drill press spindle

a. Drift

b. Drill chuck

c. Morse taper

d. Quic[illegible] hange chuck

e. Sleeve

ab. Socket

ac. Tapered spindle

ad. Tapping attachment

ANSWERS TO AS 1.1

1. c
2. a
3. ad
4. b
5. e
6. ab
7. ac
8. d

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT VI: TOOLS AND TOOL HOLDERS

LESSON 2: CUTTING TOOL TERMS AND TYPES

I. Terms and definitions **(TM 2.1)**

A. Center drill--short combination drill and countersink which provide a hole with a tapered top so that the drill will start in the desired location without wandering

B. Chamfer--formed by deburring a hole with a countersink to prepare the hole for reaming or tapping or to protect the end of the hole

C. Counterboring--the tool and process of enlarging an existing hole. The tool is guided by a pilot to assure concentricity.

D. Countersink--tool and process of making a conical enlargement of an existing hole

E. Drill--end-cutting, rotary-type tool which has one or more cutting lips and flutes and is used for producing rough holes

F. Pilot hole--small hole used to guide a larger drill. This hole is approximately the same size as the web of the larger drill.

G. Reams--tools usually used to produce a finished hole but are also used to enlarge or align an existing hole

H. Spotfacing--process of using a counterboring tool to produce a flat surface perpendicular to a hole. The process is usually used on castings or bosses.

I. Straight shank--straight portion of the cutting tool that is gripped and aligned by the tool holder

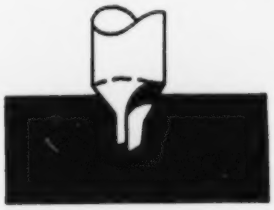
J. Tang--flat portion of a tapered-shank tool which gives the tool a positive drive

K. Tapered shank--tapered portion of a cutting tool that is gripped and aligned by the spindle

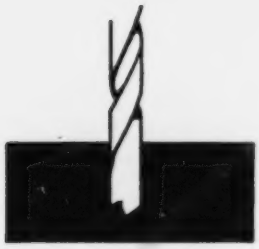
L. Tapping--producing a screw thread in a specifically sized hole

II. Cutting tools and operations **(HO 2.1)**

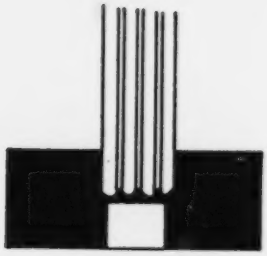
A. Center drill



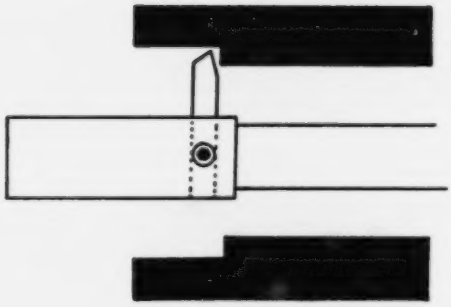
B. Drill



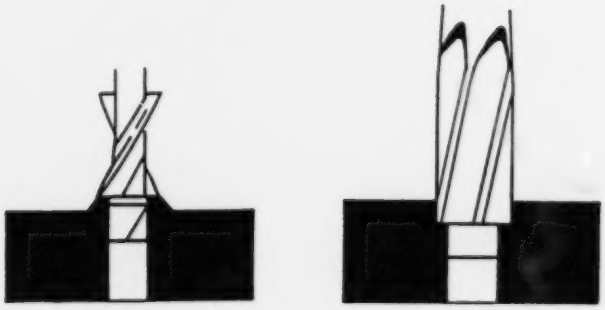
C. Reamer



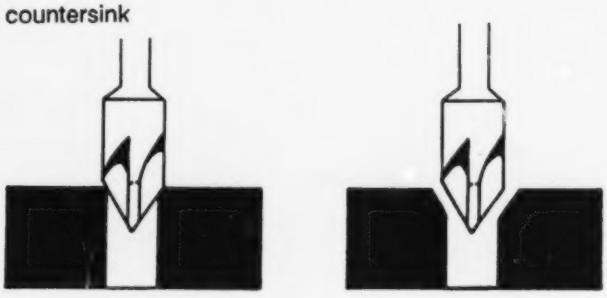
D. Boring tool



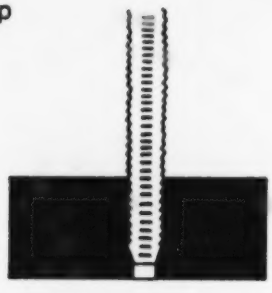
E. Spotface and counterbore



F. Chamfer and countersink



G. Tapping attachment and tap



III. Speed and feed calculation charts **(HO 2.2, 2.3)**

NOTE: Figures are only suggested and must be adjusted to fit the job.

A. The simplified formula for finding the optimum revolutions per minute (rpm) for a high speed drill bit is as follows.

$$rpm = \frac{CS \times 4}{D}$$

rpm = revolutions per minute
CS = Cutting speed of the material in surface feet per minute (sfpm)
D = Diameter of the drill

1. For carbon-steel bits, use one-half the rpm for high-speed drills.

2. For carbide tools use approximately 2-5 times the rpm for high-speed tools.

B. Optimal cutting speeds for high-speed drills

Steel castings	40 sfpm
Tool steel	60 sfpm
Cast iron	80 sfpm
Machine steel	100 sfpm
Brass and aluminum	200 sfpm

C. Optimal feed rates for high-speed steel drills

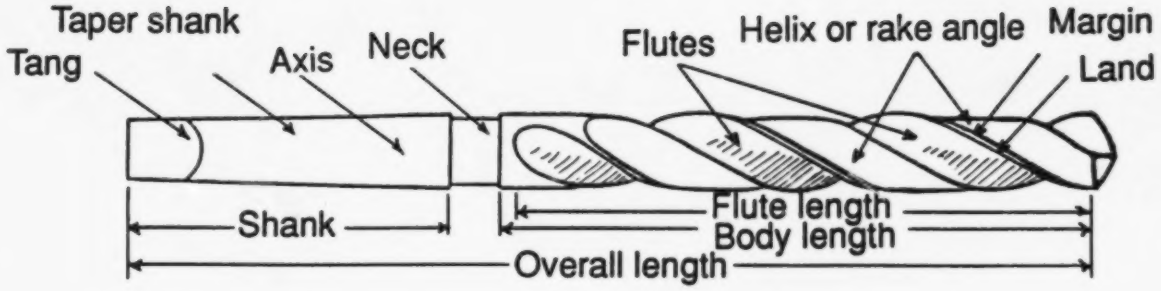
1/8" and smaller	0.001 to 0.002"
1/8" to 1/4"	0.002 to 0.004"
1/4" to 1/2"	0.004 to 0.007"
1/2" to 1"	0.007 to 0.015"
1" to 1 1/2"	0.015 to 0.025"

D. During reaming operations, use one-half to two-thirds the rpm and 3-4 times the feed rate for drilling the same material.

E. During spotfacing, counterboring, chamfering, countersinking and boring, use approximately one-quarter the rpm for drilling the same material.

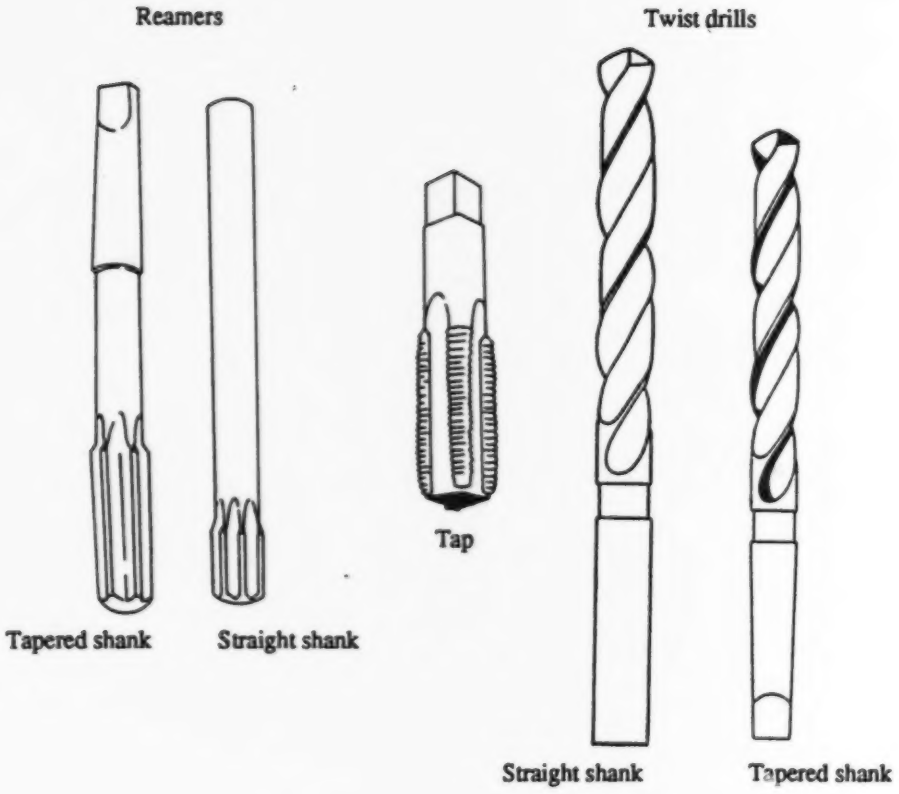
F. During tapping, do not exceed 100 rpm.

PARTS OF A DRILLING TOOL



Credit: Dunn, James. Machine Shop I. Stillwater: Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1981, pg. 103C.

CUTTING TOOLS AND OPERATIONS



CUTTING SPEEDS

Drill Size	FEET PER MINUTE									
	10	20	30	40	50	60	70	80	90	100
	REVOLUTIONS PER MINUTE									
#0	2829	5660	8490	11320	14150	16980	19810	22640	25470	28300
79	2634	5268	7902	10536	13170	15804	18438	21072	23706	26340
1/64	2444	4888	7332	9780	12224	14784	17252	19716	22180	24646
78	2387	4774	7161	9548	11935	14322	16709	19096	21483	23870
77	2122	4244	6366	8488	10610	12732	14854	16976	19098	21220
76	1910	3820	5730	7640	9550	11460	13370	15280	17190	19100
75	1819	3638	5457	7276	9095	10914	12733	14552	16371	18190
74	1702	3404	5106	6808	8510	10212	11914	13616	15318	17020
73	1592	3184	4776	6368	7960	9552	11144	12736	14328	15920
72	1528	3056	4584	6112	7640	9168	10696	12224	13752	15280
71	1473	2946	4419	5892	7365	8838	10311	11784	13257	14730
70	1364	2728	4091	5456	6820	8184	9548	10912	12276	13640
69	1306	2612	3918	5224	6530	7836	9142	10488	11754	13060
68	1232	2464	3696	4928	6160	7392	8624	9856	11088	12320
1/32	1222	2444	3666	4890	6112	7332	8554	9776	10998	12222
67	1194	2388	3582	4776	5970	7164	8358	9552	10746	11940
66	1158	2316	3474	4632	5790	6948	8106	9264	10422	11580
65	1091	2182	3273	4364	5455	6546	7637	8728	9819	10910
64	1061	2122	3183	4244	5305	6366	7427	8488	9549	10610
63	1032	2064	3096	4128	5160	6192	7224	8256	9288	10320
62	1005	2010	3013	4020	5025	6030	7035	8040	9045	10050
61	979	1959	2938	3918	4897	5876	6856	7835	8815	9794
60	955	1910	2865	3820	4775	5730	6684	7639	8594	9549
59	932	1863	2795	3726	4658	5590	6521	7453	8385	9316
58	909	1819	2729	3637	4547	5457	6366	7276	8185	9095
57	888	1776	2664	3553	4442	5330	6218	7106	7995	8883
56	836	1672	2508	3286	4180	5016	5852	6688	7524	8360
3/64	830	1660	2491	3286	4108	4982	5813	6644	7474	8305
55	734	1469	2204	2938	3673	4407	5142	5876	6611	7346
54	694	1389	2084	2778	3473	4167	4861	5556	6250	6945
53	641	1283	1924	2566	3207	3884	4532	5179	5827	6474
1/16	611	1222	1833	2445	3056	3696	4313	4929	5545	6111
52	601	1203	1805	2406	3008	3638	4244	4850	5457	6015
51	570	1140	1710	2280	2851	3421	3991	4561	5131	5701
50	546	1091	1637	2183	2729	3274	3820	4366	4911	5457
49	523	1046	1570	2093	2617	3140	3663	4186	4710	5233
48	502	1005	1508	2010	2513	3016	3518	4021	4523	5026
47	486	973	1460	1946	2433	2938	3428	3918	4407	4866
5/64	486	973	1460	1946	2433	2938	3428	3918	4407	4866
46	471	943	1415	1886	2358	2829	3301	3773	4244	4716
45	466	931	1397	1863	2329	2795	3261	3727	4192	4658
44	444	888	1333	1777	2221	2665	3109	3553	3997	4442
43	429	856	1288	1717	2146	2575	3004	3433	3863	4292
42	408	817	1226	1634	2043	2464	2875	3286	3696	4085
3/32	408	817	1226	1634	2043	2464	2875	3286	3696	4085
41	399	796	1194	1592	1990	2387	2785	3183	3581	3979
40	390	779	1169	1559	1949	2339	2728	3118	3508	3898
39	383	768	1152	1536	1920	2315	2701	3087	3472	3839
38	376	752	1129	1505	1882	2269	2647	3026	3404	3764
37	367	734	1102	1469	1837	2204	2571	2938	3306	3673
36	359	717	1076	1435	1794	2162	2522	2883	3243	3587
7/64	349	698	1048	1396	1748	2103	2453	2803	3154	3492
35	347	694	1042	1389	1736	2083	2431	2778	3125	3472
34	344	688	1033	1376	1721	2065	2409	2753	3097	3442
33	338	676	1014	1352	1690	2028	2366	2704	3042	3380
32	329	659	988	1317	1647	1976	2305	2634	2964	3293
31	318	636	955	1273	1592	1910	2228	2546	2865	3183
1/8	306	611	917	1222	1528	1833	2139	2445	2750	3056
30	297	594	892	1189	1487	1790	2089	2387	2686	2973
29	281	562	843	1124	1405	1685	1966	2247	2528	2809
28	272	544	816	1088	1360	1637	1910	2183	2456	2719
9/64	272	544	816	1088	1360	1637	1910	2183	2456	2719
27	265	530	796	1061	1327	1592	1857	2122	2387	2653
26	260	519	779	1039	1299	1559	1819	2079	2339	2598
25	255	511	767	1022	1276	1538	1794	2051	2307	2555
24	251	502	754	1005	1257	1508	1759	2010	2262	2513
23	248	496	744	992	1240	1488	1736	1984	2232	2480
5/32	244	489	734	978	1222	1469	1714	1959	2204	2444
22	243	486	730	973	1217	1460	1703	1946	2190	2433
21	240	480	721	961	1201	1441	1682	1922	2162	2402
20	237	474	712	949	1186	1423	1661	1898	2135	2372
19	230	460	690	920	1151	1381	1611	1841	2071	2301
18	226	452	678	904	1130	1356	1582	1808	2034	2260
11/64	222	444	666	888	1111	1340	1564	1787	2010	2221
17	220	441	662	883	1104	1325	1546	1766	1987	2208
16	216	431	647	863	1079	1295	1511	1726	1942	2158
15	213	425	638	851	1064	1273	1485	1698	1910	2127

Drill Size	FEET PER MINUTE									
	10	20	30	40	50	60	70	80	90	100
	REVOLUTIONS PER MINUTE									
14	210	420	630	840	1050	1259	1469	1679	1889	2099
13	206	413	620	826	1032	1239	1445	1652	1858	2065
3/16	204	407	611	815	1019	1226	1430	1634	1838	2037
12	202	404	606	808	1010	1213	1415	1617	1819	2021
11	200	400	600	800	1000	1200	1400	1600	1800	2000
10	197	393	592	790	987	1187	1385	1583	1781	1974
9	195	390	585	780	975	1169	1364	1559	1754	1949
8	192	384	576	768	960	1152	1344	1536	1728	1919
7	190	380	570	760	950	1140	1330	1520	1710	1900
13/64	188	376	565	753	941	1129	1317	1505	1693	1882
6	187	374	562	749	936	1123	1311	1498	1685	1872
5	186	372	558	744	930	1115	1301	1487	1673	1859
4	183	365	548	731	914	1097	1279	1462	1645	1828
3	179	358	538	717	897	1076	1255	1435	1614	1793
7/32	174	349	524	698	874	1051	1227	1402	1577	1746
2	173	345	518	691	864	1037	1210	1383	1556	1728
1	167	335	503	670	838	1005	1173	1340	1508	1675
A	163	326	490	653	816	979	1143	1306	1469	1632
15/64	163	326	490	653	816	979	1143	1306	1469	1632
B	160	321	482	642	803	963	1123	1284	1444	1605
C	157	315	473	631	789	947	1105	1263	1421	1574
D	155	311	467	622	778	933	1087	1242	1398	1556
E	153	305	458	611	764	917	1070	1222	1375	1528
1/4	153	305	458	611	764	917	1070	1222	1375	1528
F	148	297	446	594	743	892	1040	1189	1338	1486
G	146	292	440	585	732	878	1024	1171	1317	1463
17/64	144	288	432	576	719	863	1009	1153	1297	1439
H	143	287	430	574	718	862	1005	1149	1292	1436
I	140	280	421	562	702	843	983	1123	1264	1404
J	138	276	414	552	690	827	965	1103	1241	1379
K	136	272	408	544	680	816	952	1087	1223	1359
9/32	136	272	408	544	680	816	952	1087	1223	1359
L	132	263	395	527	659	790	922	1054	1185	1317
M	129	259	388	518	648	777	906	1036	1165	1295
19/64	128	257	386	515	643	774	903	1032	1161	1288
N	126	253	380	506	633	759	885	1012	1138	1265
5/16	122	244	367	489	611	735	857	979	1102	1222
O	121	242	363	484	605	725	846	967	1088	1209
P	118	236	355	473	592	710	828	946	1064	1183
21/64	116	232	349	465	581	699	815	932	1048	1162
Q	115	230	345	460	575	690	805	920	1035	1150
R	113	225	338	451	564	676	789	901	1014	1127
11/32	111	222	333	444	555	668	780	891	1002	1110
S	110	220	329	439	549	659	768	878	988	1098
T	107	213	320	426	533	640	747	854	960	1066
23/64	106	212	319	425	532	638	745	851	958	1062
U	104	207	311	415	519	623	727	830	934	1038
3/8	102	204	306	407	509	611	713	815	917	1019
V	101	202	304	405	507	608	709	811	912	1013
W	99	198	297	396	495	594	693	792	891	989
25/64	98	195	293	391	488	586	684	781	879	977
X	96	192	289	385	481	577	673	770	866	962
Y	95	189	284	378	473	567	662	756	851	945
13/32	94	188	282	376	469	564	659	753	847	939
Z	93	185	277	370	462	555	647	740	832	925
27/64	90	181	271	361	452	544	635	726	817	904
7/16	87	175	262	349	437	524	612	699	787	873
29/64	84	168	253	337	421	506	590	675	759	842
15/32	81	163	244	326	407	490	571	653	735	815
31/64	79	158	237	316	394	474	552	631	710	789
1/2	76	153	229	306	382	458	535	611	688	764
17/32	72	144	216	288	360	432	504	576	648	719
9/16	68	136	204	272	340	408	476	544	612	679
19/32	64	128	192	256	322	384	448	512	576	640
5/8	61	122	183	244	306	366	427	488	549	611
21/32	58	116	174	232	291	348	406	464	522	582
11/16	56	112	168	224	279	336	392	448	504	556
23/32	53	106	159	212	266	318	371	424	477	531
3/4	51	102	153	204	255	306	357	408	459	509
25/32	49	98	147	196	244	294	343	392	441	489
13/16	47	94	141	188	235	282	329	376	423	470
27/32	45	90	135	180	226	270	315	360	405	451
7/8	44	88	132	176	218	264	308	352	396	437
29/32	42	84	126	168	211	252	294	336	378	421
15/16	41	82	123	164	204	246	287	328	369	407
31/32	39	78	117	156	197	234	273	312	351	394
1	38	76	114	152	191	228	266	304	342	382

Credit: Cutting Tools, Mohawk Tools Co. A Precision Twist Drill Company

DECIMAL EQUIVALENTS: WIRE, LETTER AND FRACTIONAL SIZES

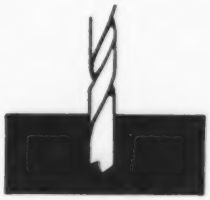
Drill Size	Decimal	Drill Size	Decimal	Drill Size	Decimal	Drill Size	Decimal
80	.0135	42	.0935	13/64	.2031	X	.3970
79	.0145	3/32	.0938	6	.2040	Y	.4040
1/64	.0156	41	.0960	5	.2055	13/32	.4062
78	.0160	40	.0980	4	.2090	Z	.4130
77	.0180	39	.0995	3	.2130	27/64	.4219
76	.0200	38	.1015	7/32	.2188	7/16	.4375
75	.0210	37	.1040	2	.2210	29/64	.4531
74	.0225	36	.1065	1	.2280	15/32	.4688
73	.0240	7/64	.1094	A	.2340	31/64	.4844
72	.0250	35	.1100	15/64	.2344	1/2	.5000
71	.0260	34	.1110	B	.2380	33/64	.5156
70	.0280	33	.1130	C	.2420	17/32	.5313
69	.0292	32	.1160	D	.2460	35/64	.5469
68	.0310	31	.1200	1/4	.2500	9/16	.5625
1/32	.0313	1/8	.1250	E	.2500	37/64	.5781
67	.0320	30	.1285	F	.2570	19/32	.5938
66	.0330	29	.1360	G	.2610	39/64	.6094
65	.0350	28	.1405	17/64	.2656	5/8	.6250
64	.0360	9/64	.1406	H	.2660	41/64	.6406
63	.0370	27	.1440	I	.2720	21/32	.6562
62	.0380	26	.1470	J	.2770	43/64	.6719
61	.0390	25	.1495	K	.2810	11/16	.6875
60	.0400	24	.1520	9/32	.2812	45/64	.7031
59	.0410	23	.1540	L	.2900	23/32	.7188
58	.0420	5/32	.1562	M	.2950	47/64	.7344
57	.0430	22	.1570	19/64	.2969	3/4	.7500
56	.0465	21	.1590	N	.3020	49/64	.7656
3/64	.0469	20	.1610	5/16	.3125	25/32	.7812
55	.0520	19	.1660	O	.3160	51/64	.7969
54	.0550	18	.1695	P	.3230	13/16	.8125
53	.0595	11/64	.1719	21/64	.3281	53/64	.8281
1/16	.0625	17	.1730	Q	.3320	27/32	.8438
52	.0635	16	.1770	R	.3390	55/64	.8594
51	.0670	15	.1800	11/32	.3438	7/8	.8750
50	.0700	14	.1820	S	.3480	57/64	.8906
49	.0730	13	.1850	T	.3580	29/32	.9062
48	.0760	3/16	.1875	23/64	.3594	59/64	.9219
5/64	.0781	12	.1890	U	.3680	15/16	.9375
47	.0785	11	.1910	3/8	.3750	61/64	.9531
46	.0810	10	.1935	V	.3770	31/32	.9688
45	.0820	9	.1960	W	.3860	63/64	.9844
44	.0860	8	.1990	25/64	.3906	1	1.0000
43	.0890	7	.2010				

Credit: Cutting Tools, Mohawk Tools Co. A Precision Twist Drill Company

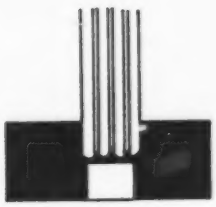
CUTTING TOOLS

Identify the following illustrations.

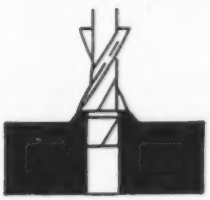
___ 1.



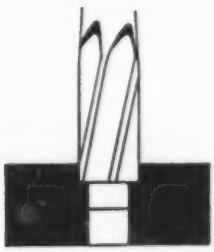
___ 2.



___ 3.

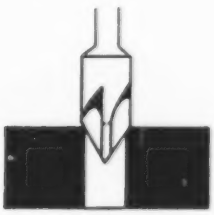


___ 4.

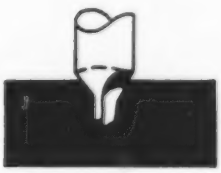


a. Center drill
b. Drill
c. Pilot hole
d. Ream
e. Chamfer
ab. Countersink
ac. Spotface
ad. Counterbore
ae. Straight shank

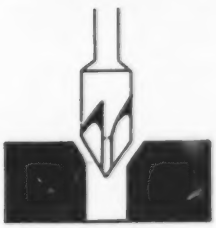
___ 5.



___ 6.



___ 7.



Mark with an "a" if the statement is true and a "b" if the statement is false.

____ 8. When tapping a hole, the drill should not be operated at speeds greater than 100 rpm.

____ 9. When reaming, the recommended feed rate is 3-4 times the feed rate for drilling the same material.

____ 10. The recommended rpm for reaming is 2-3 times higher than the drilling speed for the same material.

____ 11. Other drilling operations such as chamfering, countersinking, boring, spotfacing and counterboring should be done at over one-quarter the rpm for drilling the same material.

ANSWERS TO AS 2.1

1. b
2. d
3. ac
4. ad
5. -
6. a
7. ab
8. a
9. b
10. b
11. a

CENTER DRILL AND DRILL A HOLE

Equipment:

Drill press with automatic feed
Drill press vise or other suitable work holder
Clamp
Workpiece which has been laid out and center punched
Wiggler
Center drill
Drill bit
Lubricant

Procedure:		Evaluation 3	2	1	N
<u>Center drilling</u>					
1.	Set the machine to the slowest speed.	—	—	—	—
2.	Secure the workpiece in the vise but do not clamp it to the table.	—	—	—	—
3.	Align the center punch mark in the workpiece directly under the spindle.	—	—	—	—
4.	Put the center drill into the spindle and bring it down into alignment with the punch mark.	—	—	—	—
5.	A wiggler may be used for more accuracy. Insert the wiggler into the spindle in place of the drill. Turn on the spindle and align the wiggler, then very gently feed the point of the wiggler into the punch mark. If the wiggler does not maintain a stable position when the spindle is raised, the spindle is not aligned with the punch mark. Repeat this procedure until there is no wobble.	—	—	—	—
6.	Without changing anything, stop the machine and clamp the vise to the table.	—	—	—	—
7.	Set the drill at the proper speed and carefully feed the center drill into the work.	—	—	—	—
8.	Raise the drill and apply a drop of cutting oil to the drill. Continue drilling but frequently raise the drill to clear the chips and apply more cutting oil. Continue to drill until the hole is adequately spotted to align the drill.	—	—	—	—
<u>Drilling the hole</u>					
9.	Remove the center drill without moving the part. If the part was moved, re-indicate the hole using the wiggler, dial indicator or a pointer.	—	—	—	—
10.	Reset the spindle speed for the selected drill bit.	—	—	—	—
11.	Select the proper feed rate.	—	—	—	—
12.	Set the depth stop.	—	—	—	—

13. Insert the drill and drill to the desired depth. Remove the drill from the hole frequently to clear chips from the flutes and to apply cutting fluid. — — — —

NOTE: The general procedure for drilling large holes (over 3/8") is to drill a small lead hole or pilot hole to overcome the excess pressure required by the web (non-cutting part) of the drill bit. Special care must be taken to assure that the pilot drill is aligned so that the larger hole will follow.

14. Remove the workpiece and deburr the hole(s) as soon as possible. — — — —

15. Using the automatic feed on the drill press, repeat the steps for drilling holes using the appropriate feed rate. — — — —

16. Clean the machine. — — — —

Average of above evaluations* — — — —

*This average is the student's final evaluation for competencies H6, 8 and 9.

BORE A HOLE

Equipment:

Drill press
Drill press vise or other work-holding device
Clamps
Workpiece which has been drilled
Dial calipers or telescoping gages
Pointer
Dial indicator
Boring bar and tool
Lubricant

Procedure:		Evaluation 3	2	1	N
1.	Mount a wide, short boring bar into the drill press spindle.	—	—	—	—
2.	Align the workpiece directly below the boring bar and make sure that the bar will clear the work.	—	—	—	—
3.	Mount the work on parallels so that chips will clear the hole and the bar will not scar the table.	—	—	—	—
4.	Lock the table in position.	—	—	—	—
5.	Remove the boring bar and insert the dial indicator into the spindle.	—	—	—	—
6.	Indicate the part by moving it and rotating the spindle by hand until the part is aligned.	—	—	—	—
7.	Clamp the part securely to the table.	—	—	—	—
8.	Replace the boring bar and set the drill for the calculated speed.	—	—	—	—
9.	Set the depth stop for the correct depth.	—	—	—	—
10.	Set the feed rate according to the material being cut. Roughing feeds can be up to 0.015", while finish cuts may be as little as 0.001".	—	—	—	—
11.	Set the tool to make a light trial cut about 1/4" deep.	—	—	—	—
12.	Measure the hole.	—	—	—	—
13.	Reset the tool for the depth of cut required.	—	—	—	—
14.	Oil the tool and the hole; continue to bore the hole to the required size by setting the cutting tool for each cut.	—	—	—	—
15.	Clean and oil the tools and carefully return to the proper storage location.	—	—	—	—
16.	Clean the drill press.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is the student's final evaluation for competency H2: Perform care and maintenance.

REAM A HOLE

Equipment:

Drill press
Drill press vise or other work-holding device
Clamps
Machine reamer
Workpiece which has been drilled to the proper dimensions

Procedure:	Evaluation 3	2	1	N
1. Measure the hole. If the hole is less than 1/2" in diameter, allow 1/64" for reaming. If the hole is more than 1/2", allow 1/32".	—	—	—	—
2. Select the proper reamer and carefully place it in the spindle.	—	—	—	—
3. Mount the workpiece in the vise.	—	—	—	—
4. Align the workpiece with the reamer. Clamp the vise, if necessary.	—	—	—	—
5. Set the depth stop.	—	—	—	—
6. Set for the correct speed and feed.	—	—	—	—
7. Begin reaming the hole. If chatter occurs, slow down the speed. Use cutting fluid for a better finish and longer tool life.	—	—	—	—
8. When the task is complete, clean and oil the reamer and carefully store it.	—	—	—	—
9. Clean the drill press.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency H14: Power-ream hole to size.

COUNTERBORE AND SPOTFACE

Equipment:

Drill press
Drill press vise
Parallels
Clamps
Counterbore
Workpiece drilled in two places to the correct size to accept the body of a screw bolt
Cutting fluid

Procedure:	Evaluation 3	2	1	N
Spotfacing				
1. Set the work securely in the vise.	—	—	—	—
2. Measure the holes. Make sure that they are the correct size for the body of the screw bolt.	—	—	—	—
3. Select the right counterbore; put it in the spindle.	—	—	—	—
4. Align the workpiece hole with the tool and secure it to the table with clamps.	—	—	—	—
5. Set the drill press for the correct speed.	—	—	—	—
6. Apply cutting fluid to the hole and to the tool.	—	—	—	—
7. Spotface the workpiece to the selected depth.	—	—	—	—
Counterboring				
8. Repeat steps 4-6.	—	—	—	—
9. Set the depth stop to the correct depth.	—	—	—	—
10. Begin counterboring. Raise the tool occasionally and apply more cutting fluid to extend the tool's life and produce a smoother cut.	—	—	—	—
11. When the task is completed, clean and oil the tool and carefully put it in its proper place.	—	—	—	—
12. Clean the drill press.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competencies H11 and H12.

CHAMFER AND COUNTERSINK

Equipment:

Drill press
Drill press vise or other work-holding device
Clamps
Countersink
Workpiece drilled in two places to the body size of a selected screw bolt
Cutting fluid

Procedure:	Evaluation 3	2	1	N
Chamfering				
1. Mount the workpiece securely in the vise. Align the workpiece with the tool.	—	—	—	—
2. Set the drill press for the correct speed.	—	—	—	—
3. Turn on the drill press and lightly contact the workpiece until the specified chamfer is obtained. Turn off the drill press.	—	—	—	—
Countersinking				
4. Mount the workpiece securely in the vise.	—	—	—	—
5. Select the correct countersinking tool for the screw bolt size and head angle and secure the tool in the drill spindle.	—	—	—	—
6. Set the drill press for the correct speed.	—	—	—	—
7. Align the tool with the hole. Clamp the vise, if necessary. Set the depth stop for the correct depth.	—	—	—	—
8. Apply cutting fluid to the hole and the countersinking tool.	—	—	—	—
9. Countersink the hole and check for the correct depth.	—	—	—	—
10. When the task is completed, clean the tool and return it to it proper storage location.	—	—	—	—
11. Clean the drill press.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency H10: Countersink hole to specifications.

TAP A HOLE BY HAND

Equipment:

Drill press
Drill press vise or clamping device
60° center to fit drill chuck
Tap for a given screw size
Tap wrench or handle
Workpiece predrilled to the tap drill size for the screw size
Cutting oil

Procedure:	Evaluation 3	2	1	N
1. Insert center in drill chuck.	—	—	—	—
2. Align workpiece hole with the drill spindle by lowering center into the predrilled workpiece hole. Clamp workpiece to the drill press table.	—	—	—	—
3. Raise the drill center from the hole; oil the hole.	—	—	—	—
4. Insert the tap into the tap handle. Put tap into the hole and lower the center into the hole in the tap handle, supporting that end. Apply more cutting oil.	—	—	—	—
CAUTION: Do <u>not</u> turn on the machine yet.				
5. Feed lightly downward with the feed handle to maintain alignment while hand-turning the tap handle with the other hand. With every turn of the tap, reverse enough to break the chip.	—	—	—	—
6. When the desired depth of thread is reached, back the tap from the hole.	—	—	—	—
7. Check that the hole was threaded to the proper depth.	—	—	—	—
8. Clean and lightly oil tools, returning them to proper storage places. Clean the drill press.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency H16: Hand-tap hole using drill press.

HAND-GRIND DRILLS ON THE PEDESTAL GRINDER

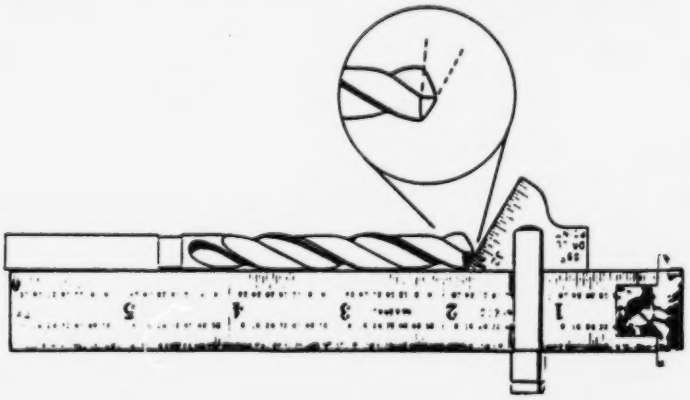
Equipment:

Pedestal grinder
Drill-point gage

Procedure:	Evaluation 3	2	1	N
1. Make sure both roughing and finishing wheels on the grinder are true.	—	—	—	—
2. Hold the drill shank in your left hand and the drill flutes near the point with the right hand. Hold the drill lightly so that it can be manipulated on the grinding wheel. The drill axis should be at 59° to the face of the wheel; the cutting lips should be at a nearly horizontal position.	—	—	—	—
3. As with any tool sharpening, cut <u>away</u> from the cutting edge to keep the tool cool.	—	—	—	—
4. Using your fingers on the tool rest as a pivot, contact the wheel lightly at the drill's cutting edge. Smoothly move the shank down and slightly to the left, maintaining wheel contact.	—	—	—	—

NOTE: On 1/2" (or smaller) drills, it is not necessary to rotate the drill bit. It <u>is</u> necessary to maintain the proper clearance angle on the heel of the drill. Do <u>not</u> touch the opposite cutting lip or edge while sharpening.

5. Without changing position, move back from the wheel and rotate the drill bit 180° until the other drill lip is in the horizontal position. Repeat step 4.	—	—	—	—
6. After grinding both lips, check with a drill-point gage for correct angle and equal lip lengths. Also, check lip clearances visually.	—	—	—	—



7. Repeat the procedure until lip lengths and drill point angles are correct.	—	—	—	—
8. Using cutting oil, drill a hole in scrap metal to verify that the drill will cut.	—	—	—	—

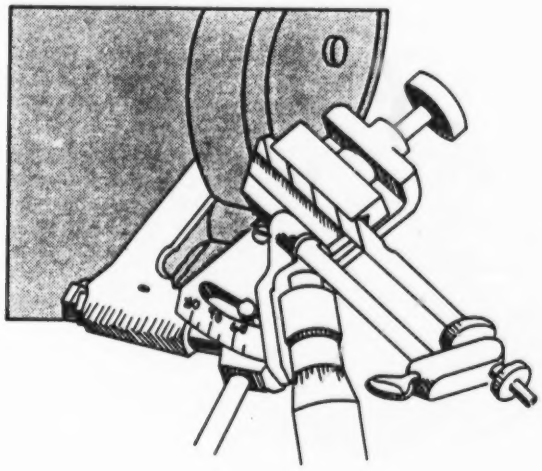
9.	Check the condition of the hole and measure it. If the hole is more than .01 times the drill diameter, resharpen and try again. If the hole is odd-shaped or if the workpiece chattered while drilling, check clearance angles and rpm. (Hand-sharpened drills normally drill up to 1% oversize, while machine-sharpened drills produce smooth, precision holes.)	—	—	—	—
10.	As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
	Average of above evaluations*	—	—	—	—

*This average is the student's partial evaluation for competency H18: Sharpen drills with grinding attachments and/or specialized grinders.

GRIND DRILL BITS WITH A DRILL GRINDER

Equipment:

Drill grinder or attachment
Oilstone



Procedure:	Evaluation 3	2	1	N
1. Remove all burrs from the shank of the drill bit with the oilstone.	—	—	—	—
2. Determine necessary angles required for the material being cut and the drilling material from manufacturer's specifications or the Machinery's Handbook.	—	—	—	—
3. Adjust the drill sharpening machine to meet all necessary specifications for the drill bit end-point geometry.	—	—	—	—
4. Set the stop for the length of the drill bit.	—	—	—	—
5. Grind both lips of the drill bit and check that it has been ground deep enough to produce a sharp edge. Repeat if necessary.	—	—	—	—
6. Visually check that the drill is properly sharpened, then test-drill a hole in a metal scrap using cutting oil. While hand-sharpened drill bits produce holes which are oversized normally by as much as 1%, machine-sharpened drills should produce a precision smoothness.	—	—	—	—

NOTE: Drill-point sharpening machines are available which grind drill bits in various manners and complexity, using pivots, cams, special wheels, etc. so that the operator can shape the drill bit. Regardless of the method used, machine drill sharpening produces a precision point. When both flutes cut evenly, drill life is increased, drill bits stay sharp longer and hole size can be kept within close limits. Special point designs (step land, sub-land, core drills, etc.) must be ground by machine--not by hand.

7. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency H18: Sharpen drills with grinding attachments and/or specialized grinders.

TAP A HOLE WITH A TAPPING ATTACHMENT

Equipment:

Drill press
Drill press vise or other work-holding device
Parallels
Clamps
Tapping attachment
Machine tap for a specified screw size
Cutting fluid
Heavy gage wire
Workpiece drilled to the tap drill size appropriate for the screw size

Procedure:		Evaluation 3	2	1	N
1.	Set the drill press speed to 100 rpm or less.	—	—	—	—
2.	Secure the tapping attachment in the spindle of the drill press.	—	—	—	—
3.	Use the heavy gage wire to loosely hold the handle of the tapping attachment to the left side of the drill press column. (This handle must be free to move up and down as the spindle moves but sturdy enough to withstand the force exerted on the handle when the tap is withdrawn.)	—	—	—	—
4.	Insert the tap into the tapping attachment.	—	—	—	—
5.	Mount the workpiece on parallels in the vise to clear the tap if it extends beyond the workpiece.	—	—	—	—
6.	Align the workpiece with the tap.	—	—	—	—
7.	Set the depth stop.	—	—	—	—
	NOTE: The friction clutches in the tapping attachment will let the tap extend further than the setting of the depth stop.				
8.	Secure the vise with a clamp.	—	—	—	—
9.	Apply cutting oil to the tap and the hole.	—	—	—	—
10.	Turn on the drill press and apply pressure to the spindle feed handle, tapping to the desired depth. (The built-in friction clutches in the mechanism, which drives the tap clockwise as the spindle is fed down, also prevent the tap from breaking if it becomes jammed or stuck by slipping.)	—	—	—	—
11.	When the desired depth is reached, release the pressure of the feed handle and the tapping attachment will automatically back out of the hole. Turn the machine off.	—	—	—	—
12.	Check the tapped hole to be sure that it was threaded to the correct depth.	—	—	—	—

13.	When the task is completed, remove the tool from the drill press, clean and lightly oil it and return it to its proper storage location.	—	—	—	—
14.	Clean the drill press.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is the student's final evaluation for competency H17.

MODULE: POWER SAW AND DRILL PRESS OPERATION

UNIT VI: TOOLS AND TOOL HOLDERS

UNIT TEST

Using HO 2.2, choose the best answer from the list below for questions 1-12.

a.	0.001-0.002"	ab.	145	bd.	735
b.	0.002-0.004"	ac.	1018	be.	2445
c.	0.004-0.007"	ad.	764	cd.	611
d.	0.007-0.015"	ae.	327	ce.	546
e.	0.015-0.025"	bc.	2037	de.	4254

____ 1. What rpm is appropriate for a 1" drill bit when drilling mild steel?

____ 2. What is the feed rate for a 1" drill bit?

____ 3. What rpm is appropriate for a 5/16" drill bit when drilling mild steel?

____ 4. What is the feed rate for a 5/16" drill bit?

____ 5. What rpm is appropriate for a 1/2" drill bit operating in cast iron?

____ 6. What is the feed rate for a 1/2" drill bit?

____ 7. What rpm is appropriate for a 3/4" drill bit when drilling brass?

____ 8. What is the feed rate for a 3/4" drill bit?

____ 9. What rpm is appropriate for a 1/8" drill bit when drilling in cast steel?

____ 10. What is the feed rate for a 1/8" drill bit?

____ 11. What rpm is appropriate for a 1/4" drill bit when drilling in mild steel?

____ 12. What is the feed rate for a 1/4" drill bit?

____ 13. Which of the following is <u>not</u> a device for holding cutting tools?

a. Chuck
b. Morse taper shank-adapter sleeve
c. Tang
d. Drill drift
e. Spindle

Match the following cutting tool terms and definitions.

____ 14. Formed by deburring a hole with a countersink to prepare the hole for reaming or tapping or to protect the end of the hole

____ 15. Process of using a counterboring tool to produce a flat surface perpendicular to a hole. The process is usually used on castings or bosses.

____ 16. Producing a screw thread in a specifically sized hole

____ 17. Short combination drill and countersink which provide a hole with a tapered top so that the drill will start in the desired location without wandering

____ 18. Small hole used to guide a larger drill. This hole is approximately the same size as the web of the larger drill.

____ 19. Straight portion of the cutting tool that is gripped and aligned by the tool holder

____ 20. Tapered portion of a cutting tool that is gripped and aligned by the spindle

____ 21. The tool and process of enlarging an existing hole. The tool is guided by a pilot to assure concentricity.

____ 22. Tool and process of making a conical enlargement of an existing hole

____ 23. Tools usually used to produce a finished hole but are also used to enlarge or align an existing hole

a. Center drill
b. Chamfer
c. Counterboring
d. Countersink
e. Drill
ab. Pilot hole
ac. Reamer
ad. Spotfacing
ae. Straight shank
bc. Tang
bd. Tapered shank
be. Tapping

24. Describe three aspects of radial drill press set-up and uses.

a.

b.

c.

ANSWERS TO UNIT TEST

1.	ad	(H6)	13.	c
2.	e	(H6)	14.	b
3.	bd	(H6)	15.	ad
4.	c	(H6)	16.	be
5.	cd	(H6)	17.	a
6.	d	(H6)	18.	ab
7.	ac	(H6)	19.	ae
8.	d	(H6)	20.	bd
9.	be	(H6)	21.	c
10.	a	(H6)	22.	d
11.	bc	(H6)	23.	ac
12.	b	(H6)		

24. Any three of the following: (H19)

a. Essentially the same set-up procedures as with other types of drill presses
b. Useful for large, heavy, difficult-to-position work
c. Distinguished by way cutting tool is positioned--arm rotates about the column; spindle can move in or out on the arm.
d. Both the arm and head have positioning locks.